



JOHNS HOPKINS UNIVERSITY CIRCULARS

Published with the approbation of the Board of Trustees

VOL. XVIII.—No. 137.]

BALTIMORE, NOVEMBER, 1898.

[PRICE, 10 CENTS.

NOTES FROM THE BIOLOGICAL LABORATORY.

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Some Ectosarcal Phenomena in the Eggs of Hydra. By E. A. ANDREWS.

Since the time when the egg development of Hydra was so well described by Nikolaus Kleinenberg in his classical paper, so much has been added by the researches of Kerschner, Korotneff, Nussbaum and Brauer, that the facts recorded in this present preliminary notice would possibly not have remained unrecorded but for the fact that these later observers restricted their work so largely to the study of preserved specimens.

A careful study of the cleavage of the eggs of the green, as well as of the brown, Hydra, in March, April and May 1898, for the purpose of enquiry into the possible existence of filose phenomena,¹ revealed peculiar activities of the clear, thin, outermost, layer of the eggs—the Ectosarc. These phenomena were to some extent comparable with typical filose threads, yet characteristically different in type from those found in other forms. The eggs were studied in their normal attachment to the living parent Hydra,

whence the cleavage groove started, till only a narrow isthmus of egg separates it from the surface (d). Here again it is not quite clear whether this part of the groove, this large passage, is exactly an enlargement of the central hole, or more or less a new formation. Finally (e) the isthmus parts, with withdrawal of yolk, and an open groove similar to the first part, but on the opposite side of the egg is opened up, with no isthmus now bridging it. The egg thus gapes open on one side; closes, and again gapes open on the opposite side.

The second cleavage and some subsequent ones are formed in much the same way. This cleavage is so strikingly similar to that recently described for *Beroë ovata* by Ernst Ziegler² as to negative his statement, (p. 41), that this mode of cleavage "*sonst nirgends in dieser Weise vorkommt*."

Considerable complications in the cleavage are introduced by amœboid movements and the formation of pseudopodia. As shown by Kleinenberg, the first cleavage is preceded by the formation of very large blunt processes,

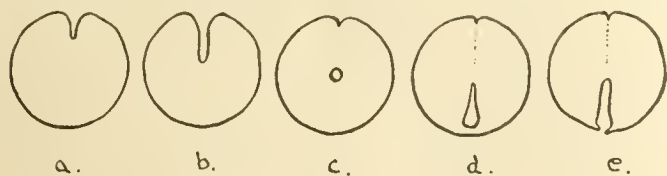


FIG. 1.

under a properly supported cover-glass. Artificially detached from the parent they develop very well, but are so soft that it was found difficult to place them as desired without injury; while if studied as normally attached, the movements of the Hydra although a source of much annoyance to the observer, often brought the egg into favorable positions.

The egg divides in the remarkable manner described by Kleinenberg. The first cleavage plane passes gradually through from one side of the egg to the other, as shown in Figure 1. The groove shown in (a) widens and deepens (b) till it nearly reaches the centre, and then closes up (c) leaving a hole at the centre. This hole is really a passage-way quite through the egg: it seems to be the bottom of the cleavage groove left in the closing of the peripheral part. Sometimes, however, it appeared to form independently and deeper in than the groove extended. This hole seems then to move along, through the egg substance, towards the side opposite to that

¹G. F. Andrews. Some Spinning Activities of Protoplasm in Starfish and Echinus Eggs. *Journal of Morphology*, XII, 1897.



FIG. 2.

or pseudopodia, which arise in a group at that pole of the egg farthest from the Hydra, Fig. 2. These may be compared to the "cleavage papillae" found in the eggs of *Cerebratulus*² and occurring in eggs of some other groups. Again they are sufficiently like the "*nasenähnliche Fortsätze*" of *Beroë* to suggest some underlying common causation. They vary in size and number as well as in time of appearance and length of duration in various eggs; thus harmonizing with the great variability in other cleavage phenomena in these protean eggs. They contain some yolk spherules and

²Experimentelle Studien über die Zelltheilung. *Archiv f. Entwicklungsmechanik*, VII, September, 1898.

³E. A. Andrews. Activities of Polar Bodies of *Cerebratulus*. *Archiv f. Entwicklungsmechanik*, VI, 1898.

flow readily like sluggish pseudopodia. When the cleavage furrow opens, some papillae, or pseudopodia, remain for some time on each edge, Fig. 3, not unlike blunt incisors in a gaping mouth.

At the time of the opening of the furrow and during its closing, there were seen much more delicate processes. These were visible as clear lines—when seen with a low power—and projected from the clear outermost part of the egg. As drawn with a camera lucida, Zeiss 4 mm. obj., and 4 eyepiece, they are represented by the black lines jutting out into the cleavage furrows in Figure 3. While the gross pseudopodia contain granular proto-



FIG. 3.

plasm and some yolk, these fine processes are wholly of the clear ectosarc that covers the egg external to its granular protoplasm. In the figures that follow, these ectosarc elevations are represented by black, though under the microscope they are highly refractive and clear. Carefully observed with 4 mm. obj., and 4, 8, or sometimes 18 eyepiece, these processes seem to be sheets and masses of clear protoplasm standing out like icebergs, or icicles, or expanses of a refractive jelly.

In Figure 4, some of them are represented as drawn with an interval of three minutes: the lower row of diagrams roughly shows some of the changes

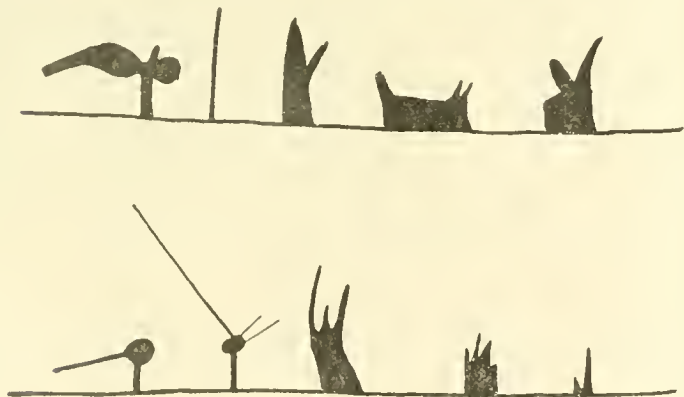


FIG. 4.

in size, shape, and direction at the end of that time. Often they change so rapidly that it is difficult to get sketches of the successive shapes.

In Figure 5 are represented successive changes in one of the processes that stood out over the rim of the furrow, far from the opposite side, till the furrow had partly closed in, when it was brought into contact with the other side, or nearly so. Later it was withdrawn into the side it sprung from, and before the final closing of the furrow. The figures were drawn at intervals of about one minute and the whole series took place in about forty-five minutes. The figures indicate only the outlines of the processes in silhouette and are necessarily very imperfect since they can show no changes in density, refraction, or thickness. Moreover, in these phenomena,

as in the kindred activities of certain leucocytes, it is almost impossible to follow the limits of some of the fine processes and films, even when the light remains constant and good. The uppermost figures represent the process figured when it appeared as a thin film, and many of its changes were due to turning the flat or the edge to view. At times it seemed to wave like a flag, and then again, its edges became crenated so that it resembled certain algae moved by a current in the water. But besides these changes, which may have been caused by outside influences, there were branchings and coalescences, increase and decrease in size, and the projection also of filaments

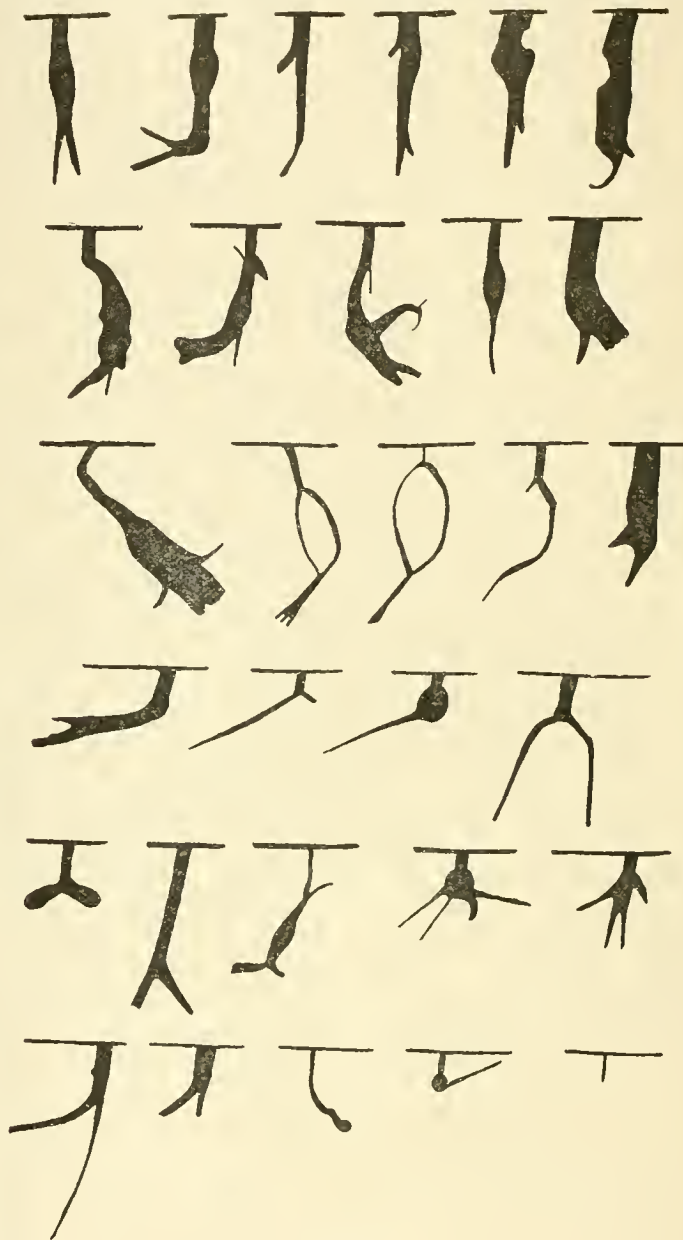


FIG. 5.

so fine as to be classed with true filose threads. Moreover, some of the movements were sudden and energetic,—thus the changes from the first to the second form shown was by a quick bend that was performed in a moment. The long forked forms seen in the lower part of the diagram reached across the cleavage furrow and their tips became indistinguishable against the opposite moiety of the egg. Apparently however, they formed no connection with it, and ultimately the whole process shrunk into a rod so minute and simple that it could have been passed by as a bacterium, had its preceding history not been observed.

The purpose of all these protean ectosarc displays was not at all obvious. At the bottom of the cleavage furrow the processes sometimes reached

across so that their tips were lost to sight over the opaque mass of the opposite part of the egg. Sometimes protoplasm flowed along in lumps on such processes, and the question suggested itself whether these ectosarcial films established intercellular currents as do some filose threads; but no definite answer was attainable at this time. In the closing up of the furrow there were thin expanses of granular protoplasm that passed like bandages or bridges from one cell half to the other, but it was not demonstrated that these had their origin in ectosarcial processes.

When the furrow had closed and a central passage was present, phenomena similar to the above were sometimes seen, but these activities were more nearly kindred to the gross pseudopodial formations, since granular protoplasm was contained in the processes which were seen at times to shoot out into, and even across, the central passage. In the later phases of the cleavage, when the isthmus was parting (*d* and *e*, Fig. 1) there were often very noticeable disturbances, both the formation of such clear ectosarcial films and processes as above described and also the shooting out of small, branching processes of a granular appearance.

In the first cleavage, these irregularities of the surface of the isthmus and the adjacent cleavage furrow, were complicated by the fact that the egg is attached to the ectoderm of the Hydra by irregular pseudopodia and these undergo changes at the end of the first cleavage. In later cleavages, the parting isthmus of connections was often drawn out into an exceedingly delicate filament that was composed almost entirely of clear ectosarc and simulated a large filose thread, so that one might have thought it was projected from one cell to the other had not one seen it produced as a faint remnant of a former gross bridge or isthmus. In the bays, or open parts of the cleavage furrows, near such reduced isthmuses, there were often most active displays of both clear ectosarcial processes like those described above, and of various granular pseudopodia both delicate and gross, some of these containing yolk.

We will summarize the preceding statements as follows:

(1) In addition to the various granular pseudopodia that accompany the remarkable cleavages of the eggs of Hydra there are peculiar disturbances of the ectosarc:—clear films and filaments being freely formed.

(2) These outgrowths of the ectosarc are formed when and where the parts of the egg are separated by considerable space and extend out into such spaces.

(3) They undergo great changes of form and of bulk and may suddenly emerge, withdraw, bend or branch.

(4) At the bottom of cleavage furrows, when closing, such ectosarcial processes may reach across the cleft to the opposite cell or mass. There is some ground for inferring that these processes are concerned in the approximation and union of separated masses of the egg, in closing in and apparent fusion of cleavage products.

(5) These ectosarcial phenomena are akin to filose phenomena: there is good reason to suppose them produced by such changes in the ectosarc as can, at present, be spoken of only as contractility. By contractions also in the material of the processes themselves, some, if not all, of their changes of form and size seem to be brought about.

(6) The presence of such activities on the surface of cleaving eggs weakens the value of surface tension as a factor in cleavage phenomena, and is not explicable along the lines of any other physical explanation yet suggested. On the other hand, these surface phenomena readily fall under those conceptions of the structure and the activities of protoplasm observed in various adult organisms, as well as eggs and embryos, that were advanced in a recent work on this subject.¹

October 12th, 1898.

A Review of Dr. F. S. Conant's Memoir on the Cubomedusae. (*Memoirs Biological Laboratory, J. H. U., Vol. IV, Part 1*).

This note, which gives an outline of the memoir by the late Dr. Conant, consists of extracts from a review, by Sidney J. Hickson, in *Natural Science*; and from a review by Prof. H. V. Wilson, in *Science*.

(From *Natural Science*, Sept., 1898, pp. 206-209.)

"There is no group of the Coelentera which needed the careful investigation of a clever student more than the one which Conant chose for the

subject of his thesis for the degree of Doctor of Philosophy at the Johns Hopkins University.

"The Cubomedusae present so many features of exceptional interest that zoologists have felt very keenly that a reinvestigation of their anatomy and a study of their development were among the most important pieces of work yet to be done in the group of the Coelentera. The investigations of Claus and Haeckel, who were able to study preserved material only, are necessarily incomplete and unsatisfactory, and Conant seized the opportunity which the discovery of large numbers of the living medusae on the coast of Jamaica gave him of reinvestigating the whole subject. There can be no doubt in the minds of those who read the volume which records the results of his labors, that this contribution to science is a solid and valuable one. His descriptive writing is remarkably lucid, his reasoning clear, and at the same time cautious, and the numerous illustrations to the memoir are admirable. With such impressions framing themselves as we read the pages, there comes the feeling that in Conant we have lost a zoologist who had every prospect before him of a brilliant career in the scientific world. His patient and noble devotion to the cause he had at heart demands our admiration, and calls out our sympathy for his friends and fellow-workers in America who mourn his untimely death.

"The species that Conant had to work upon were *Charybdea xaymacana* and *Tripedalia cystophora*, both of which were found in Kingston Harbor, Jamaica, the latter being the sole representative of the new family Tripedaliidae. The habit of these two species is not their least remarkable feature. The Cubomedusae were generally considered to be deep-sea forms, but both these species are found at the surface and near the shore. *Tripedalia* occurs—very locally—in water that is not only very shallow but discolored with organic matter, with a bottom of black mud.

"*Tripedalia* is the smallest form of the Cubomedusae, the height of the bell in the largest individuals being only 8 or 9 mm., whereas of the twenty species mentioned by Haeckel only two are less than 20 mm. in height. The generic name is given to it on account of the prominent feature of the arrangement of the tentacles in groups of three, with separate pedalia. Further details of the anatomy of this new genus are given in the text.

"The greater part of the dissertation is occupied by an admirably lucid account of the anatomy of *Charybdea xaymacana*, containing several new points of interest; but perhaps the most important part is the detailed description of the vascular lamellae and the nervous system of the Cubomedusae at the end of the volume. It will be noted with some interest that Schewiakoff's account of the histology of the eyes was not confirmed in all details. It will be remembered that Schewiakoff recognized in the retina two kinds of cells which he named visual cells and pigment cells respectively. This Conant was unable to do; in fact he found considerable evidence against the two types of retinal cells, and he found that the long pigment streaks are parts of retinal cells continued into processes like Schewiakoff's visual cells."

(From *Science*, Oct. 7, 1898, pp. 481-484.)

"The account of the Cubomedusan structure given by Dr. Conant is succinct but comprehensive. The deep, four-sided bell bears a tentacle (or in some species a bunch of tentacles) at each angle. On each lateral surface, at a higher level than the tentacles, is situated a niche into which projects a sense-organ. The primitively undivided (Scyphistoma condition) gastrovascular space is here differentiated into a central stomach and a peripheral portion lying in the lateral wall of the bell. The peripheral portion is subdivided into four stomach pockets by linear partitions, lying in the plane of the tentacles and therefore interradial. These partitions (cathammae) are mere strips of entodermal lamella, produced by the fusion between the entodermal linings of ex- and sub-umbrella. The cathammal lines stop short of the tentacles, leaving an undivided peripheral portion of the primitive space, by means of which the four stomach pockets communicate with one another. As Conant points out, the arrangement recalls the gastrovascular system of many Hydromedusae, with the difference that in the Cubomedusae the radial canals are wide 'stomach pockets' and the cathammal plates are narrow lines. When we come, however, to the extreme peripheral portion of the gastrovascular system, we find that the likeness is not with the Hydromedusae, but with the lobed Scyphomedusae. The gastrovascular space, to be brief, does not end with an even circular edge at the bell margin, as is the rule in the former group, but is divided into

¹G. F. Andrews. *The Living Substance*. Journal of Morphology, Vol. XI, 1897.

separate lobes (marginal pockets) extending into the velum (as velar canals). Conant does not dwell on phylogenetic inferences, but evidently inclines to the belief that the ancestors of the Cubomedusae possessed a margin divided into sixteen lobes. The present position of the four sense organs indicates the site of the original margin, 'which elsewhere has grown down and away from its former level, leaving the sensory clubs like floatage stranded at high-water mark.' Fusion between adjacent lobes, involving the ectoderm and jelly, gave to the medusa a continuous margin and a 'velum,' but, owing to the incompleteness in the fusion of the *entodermal linings* of the several lobes, the latter still retain in the adult Cubomedusa enough of their individuality to indicate their former condition. In a word, the marginal pockets of the existing Cubomedusa are to be construed as entodermal linings of once separate lobes.

"This conclusion as to the morphology of the marginal pockets derives much support from the behavior of a puzzling structure, called by Conant the marginal lamella. Unlike the true vascular lamella, which simply connects one entodermal cavity with another, the marginal lamella extends from the entoderm of the gastrovascular space to the ectoderm of the bell margin. It is a narrow strip which follows the outline of the marginal pockets, travelling in the radii of the sense organs far away from the actual edge of the bell, and surrounding the sense organs in such a way as to indicate clearly that they were once at the bell margin. The marginal lamella seems to be a functionless, rudimentary organ. Claus, whose imperfect description of the structure did not bring to light its morphological interest, as indicating the site of the ancestral bell margin, suggested that it was perhaps the vestige of a ring canal. Conant naturally is skeptical of this explanation of a lamella connecting ento- and ectoderm. The true meaning of this peculiar lamella is a point well worth working up, more especially as it is not confined to the Cubomedusae, but has been observed in the ephyra lobes of discophores (*Rhizostoma*).

"Before leaving this subject of the general body-plan, it may be mentioned that while the probability is that the Cubomedusae are descended from stalked ancestors (*Lucernaria*-like forms), and hence that the apex of the exumbrella was once drawn out into a peduncle, there is in the adult Cubomedusa no trace externally nor internally of this hypothetical stalked condition. Light on this very interesting point can only be expected from a study of the development.

"Unlike the other Scyphomedusae studied, the Cubomedusae possess a nerve ring. In their study of the nervous system Claus and Conant both depended on sections, and naturally the results are not so satisfactory as those reached by the Hertwigs on the Hydromedusae mainly with the aid of macerations. Claus describes the neuro-epithelium as consisting of alternating supporting cells and sensory cells, the inner ends of the latter becoming continuous with the nerve fibres. Conant makes it doubtful whether this is the actual condition, since he does not find the sensory cells. He offers, however, no observations on the origin of the 'nerve fibres.' Macerations will probably show the connection of these fibres with at least some of the neuro-epithelium cells.

"The possession of a nerve ring has been regarded (Claus) as a point of essential similarity between the Cubomedusae and the Craspedota. The main ring in the former group is obviously a differentiation of the epithelium of the subumbrella, and Claus, therefore, interprets it as homologous with the inner Craspedote ring. In the immediate neighborhood of each sense organ there are given off from the main ring two roots which *ceasing to be superficial bands* pass through the jelly, and emerge on the outer wall of the bell (on the floor of the sensory niche). They converge and unite, forming a superficial nerve tract which crosses the base of the sense-club. These four isolated tracts are regarded by Claus as the remnants of a once continuous exumbrellal ring, such as is found in the Hydromedusae, and which here, as in the Hydromedusae, stands in connection with the subumbrellal ring through the medium of fibres that perforate the jelly. Conant, on the other hand, regards the tracts lying across the bases of the sense organs as portions of the primitive subumbrellal ring which were shut off from the main ring when the marginal lobes grew together. With the Hertwigs and Haeckel he thus looks on the ring as not homologous with that of the Craspedota, but as a special differentiation of the plexus of the subumbrella, found throughout the Scyphomedusae."

The Echinoids and Asteroids of Jamaica. By HUBERT LYMAN CLARK.

While enjoying the privileges of the Marine Laboratory of the Johns Hopkins University at Port Henderson, Jamaica, in 1896, and again at Port Antonio, in 1897, I felt the need of some means of identifying the Echinoderms which we found. Collections were made of all the species found, and upon these the following list is based, though I have had the opportunity of examining in addition the collections, now in the Appleton Cabinet of Amherst College, made in Jamaica some forty years ago by Prof. C. B. Adams. My own collections were made in Kingston Harbor, chiefly near Port Royal, and on the Cays which lie off its entrance on the south side of the island, and at Montego Bay and Port Antonio on the north side. They were made during the months of May, June and July, 1896, and July and August, 1897. The Ophiurids have been placed in other hands for identification, while the Holothurians, which in those waters are the most numerous and noticeable of the Echinoderms, will be treated of in a later paper.

This list of Echinoids and Asteroids is not supposed to be exhaustive, as very little dredging was done, and none at all in water over six or seven fathoms deep, but it is hoped that it may be of use in two ways. Primarily in making the identification of the different species easy for future students and visitors to the island, and secondarily in throwing some light on the distribution of the littoral Echinoderms in the West Indies. The paper by Dr. G. W. Field in the Johns Hopkins University *Circular* for April, 1892, on the "Echinoderms of Kingston Harbor," has been of the greatest assistance in the preparation of this somewhat more extended list.

THE ECHINOIDS.

The identification of the Echinoids has been made easy by the works of Professor Alexander Agassiz. Sea-urchins are abundant everywhere that I have been on the coast of Jamaica, though the number of species is small, but Clypeasteroids and Spatangoids are not common on the south side of the island.

Order: Cidaroida.

Family: Cidaridae.

1. *Cidaris tribuloides* (Lamk.).

Easily recognized by its thick, blunt spines, which are often overgrown with animal or vegetable incrustations. Natural color, reddish or purplish brown; secondary spines almost white, with dark brown tips. Size medium, the test seldom exceeding 60 mm. in diameter. Common on the Cays near Kingston, where the specimens usually have the spines quite clean. Very abundant at Port Antonio, especially in East Harbor, and there the spines are very much overgrown with Algae. The reproductive organs were not near maturity in any specimen examined.

Order: Diadematoidea.

Family: Diademataidae.

2. *Diadema setosum* (Gray).

Readily distinguished from the other sea-urchins by its very long, slender spines, large size and dark color. The test may be 100 mm. in diameter and the spines twice that in length. The color is usually a very dark reddish or purplish brown, almost black, but specimens are common which have the spines banded brown and white, and sometimes almost wholly white specimens are found. Light color seems to be especially characteristic of very small, presumably young specimens. Abundant about coral reefs everywhere in Jamaica.

Family: Echinometridae.

3. *Echinometra subangularis* (Leske).

Very variable in size and shape, as well as in color. Ambitus sometimes circular, but usually elliptical, with a long diameter of about 60 mm. and a short one of 53. Test somewhat flattened. Spines rather stout, but sharp pointed. Color varies from very light to very dark reddish brown, while the spines often appear iridescent violet-green. Abundant on the Port Henderson side of Kingston Harbor, but especially so in the East Harbor at Port Antonio, near Folly Point.

4. *E. viridis* (A. Ag.).

Similar to the foregoing, but may be distinguished by the "bare abactinal system with equally developed genital plates." I have not met with this species myself, but there are several specimens from Jamaica in the Adams collection, and I feel confident that a careful search would show it to be more or less common in the same situations as *E. subangularis*.

Family: Echinidae.

5. *Toxopneustes variagatus* (Lamk.).

Readily distinguished by its green and white coloration, though the spines are often tipped with purplish, and rarely they are wholly white. Test about 70 mm. in diameter,

slightly flattened; ambitus circular. Very abundant in Kingstoo Harbor everywhere. In some places the bottom seems literally paved with them. In three hauls of a small dredge off Port Henderson, 856 specimens were obtained. Much less common on the north side of the island, but a few specimens were met with in the East Harbor at Port Antonio. Sexual products are ripe all summer and artificial fertilization is extremely easy.

6. *Hipponoe esculenta* (Leuke).

The large size and light color of this urchin easily distinguishes it from the other Jamaican Echinoids. Test usually delicate purplish, 100 to 125 mm. in diameter. Spines short, white, closely crowded. Very small specimens often are rather yellowish and likely to be confused with *Toxopneustes*, but they may be recognized by the absence of large imbricating plates on the buccal membrane. Common on the Cays near Kingston, especially Rackum Cay. Very common at Port Antonio, especially in East Harbor near Folly Point. Sexual products were ripe in June and July, and artificial fertilization was successful.

Order: Clypeastroida.

Family: Clypeastridae.

7. *Clypeaster subdepressus* (Gray).

Called by the colored boys "sea-moon." Recognized by the very flat actinal surface and its thinness in proportion to length and breadth. My best specimen measures 175 mm. in length, 135 in breadth and only 25 in greatest thickness. Agassiz says, however, that the proportions vary greatly. Color, yellowish green, deep brown or rich dark reddish purple. Three fine specimens were obtained in Kingston Harbor, near Fort Augusta, and I collected on the reef at Port Antonio a small clypeastroid which, with some hesitation, I refer to this species.

8. *Echinanthus rosaceus* (Lamk.).

Easily distinguished by its highly arched test and deeply sunken mouth. My best specimen measures 76 mm. in length, 62 in breadth and 33 in height; the mouth is sunk 20 mm. below the edge of the test. Color, uniform dark brown. Not seen alive on the south side of the island, but several specimens were taken at Port Antonio, on the northwest side of Navy Island. They were found in the sand underneath large slabs of coral rock.

Family: Scutellidae.

9. *Mellita sexforis* (A. Ag.).

This delicate "sand-dollar" may be known by the flatness of the test and the six lunules. The color of the living animals is a light olive-green. My largest specimen is nearly circular, and has a diameter of 55 mm. Not seen about Kingston, but quite common in the East Harbor at Port Antonio.

10. *M. testudinata* (Klein).

Distinguished from the foregoing by being more highly arched and having only five lunules. I did not meet with this species myself, but a handsome bleached test (65 x 50 mm.) from Jamaica is in the Adams collection.

Order: Spatangoida.

Family: Echinoneidae.

11. *Echinoneus semilunaris* (Gmel.).

Elliptical, somewhat flattened Echinoid, with five equal, simple, narrow ambulacra, extending from apex to mouth. In living specimens the spines are light brown, while the feet are usually bright red, causing the ambulacra to appear with great distinctness. Most of the specimens found were less than 25 mm. long, but one test measures 46 x 37 mm. This species is found, though not very common, on Rackum and Drunkenman's Cays, near Kingston, but it is abundant at Port Antonio, especially on the Fort Reef. They occur usually in the sand beneath broken slabs of coral rock, though they sometimes cling to the underside of the rock itself. They can burrow in the sand with some rapidity, and are easily overlooked. The sexual products seemed to be ripe early in August.

Family: Spatangidae.

12. *Brisrus unicolor* (Klein).

Oval spatangoids of small size and uniform light grayish brown color. Large specimens measure about 80 mm. long, 65 wide and 42 high, but most of those found were very much smaller. Not seen on the south side of the island, but very common at Port Antonio, in company with the foregoing, which in habits it somewhat resembles.

13. *Meoma ventricosa* (Lamk.).

Recognized at once by its large size. Near Kingston it occurs in water of two or three fathoms depth on the harbor side of Drunkenman's Cay, just outside the reef, where we collected a dozen specimens in two hauls of a small dredge. At Port Antonio they were found in two fathoms of water on the sandy bottom directly south of Navy Island, where they were obtained by diving for them. Superficially, the specimens from these two localities are so different, I can hardly convince myself they are the same species. Those from Drunkenman's Cay are dark brown, and measure about 95 mm. long, 75 broad and 40 high, while the specimens from Port Antonio are twice as large, more highly arched, and of rather a light yellowish brown color.

THE ASTEROIDS.

The identification of the star-fish collected has been a matter of no little difficulty, owing to the lack of good descriptions and figures of the West Indian littoral forms. Star-fish are not abundant at any point in Jamaica that I have visited, though one or two species are reasonably common at

Port Royal. I feel sure that careful search and a little dredging would add materially to the following list.

Order: Phanerozoonia.

Family: Astropectenidae.

Astropecten.

The Jamaican species of this genus may be easily recognized by the very flat abactinal surface, covered with paxillae, the very large and prominent marginal plates, and the light color. They are of medium size, generally less than 125 mm. across, and are usually reddish or yellowish white, but often a light greenish gray.

1. *A. articulatus* (Say).

This species may be recognized by the absence of spines on the superior marginal plates, but near the distal end of the ray each of these plates bears a single, small, blunt tubercle. The tops of the paxillae are granular, and the long spines on the inferior marginal plates are blunt and much flattened. Occurs in Kingston Harbor, chiefly near Port Royal, and also at Montego Bay, but no *Astropectens* were found at Port Antonio. The specimens obtained were collected on sandy bottom, in very shallow water, among or near mangroves.

2. *A. duplicatus* (Gray).

Distinguished by the long, sharp, conical, erect spines on the superior marginal plates. Tops of the paxillae with 8 or 9 rather long blunt spines. Not uncommon in Kingston Harbor, near Port Royal, on sandy bottom, in very shallow water, near mangroves. Not seen on the north side of the island.

3. *A. antillensis* (Lütken.).

In the Adams collection there are several specimens of *Astropecten*, labelled "*Astropecten antillensis*, Jamaica," which differ from the foregoing species in the absence of spines and tubercles on the superior marginal plates. The spines on the inferior marginal plates are somewhat cylindrical, and the tops of the paxillae are granular. While these specimens, which are in a wretched state of preservation, may be *articulatus*, *antillensis* probably occurs in Jamaica, and I feel no hesitation in including it in this list.

Luidia.

Star-fish of this genus may be distinguished from those of the preceding by the absence of the prominent superior marginal plates. They are also considerably larger, and the rays are much longer in proportion to the size of the disc.

4. *L. alternata* (Say).

Large star-fish, 250 mm. across, of a dark olive green or a purplish color above, with irregular yellowish bands across the rays, and the actinal surface entirely yellow. Paxillae rather small, closely crowded, bearing numerous spines, of which the central one is most evident, especially along the sides of the ray, where they are very prominent. Lower surface very spiny. Abactinal surface somewhat flattened. Rays five, considerably arched. A single specimen of this handsome star-fish was collected on muddy bottom near the mangroves at Port Royal.

5. *L. clathrata* (Say).

Easily recognized by the bluish gray color of the flattened abactinal surface and the closely crowded granular paxillae. The latter, especially those in the two rows on the outer edges of the rays, have almost rectangular tops, and bear numerous granules or short blunt spines of uniform length. The actinal surface is very light yellowish or white. Rays, five. Whole star-fish about 200 mm. across. Rather common about Port Royal, on sandy bottom, near mangroves, but not seen on the north side of the island. Two specimens in the Adams collection, labelled "*Luidia clathrata*, Jamaica," differ very plainly from those I collected at Port Royal. The abactinal surface of the rays is much more convex, and the spines of the actinal surface are quite different in size and shape. The paxillae, moreover, bear about 8 or 9 short blunt spines, instead of about 15 large granules. I think it very possible that there are two *clathrata*-like species occurring in Jamaica.

6. *L. senegalensis* (Lamk.).

In general appearance similar to *clathrata*, but readily distinguished by having nine rays. The single specimen of this remarkable star-fish which I collected measures nearly 300 mm. across. It was found near Port Royal on sandy bottom. A few days later the imprint in the sand of another specimen was noticed near the same place. Dr. Field speaks of two specimens of a star-fish which he thinks belonged to this species, being dredged in Kingston Harbor, off Fort Augusta, so I am inclined to think it is probably not rare on the south side of the island.

Family: Pentagonasteridae.

7. *Pentagonaster parvus* (Perrier).

It is only after a great deal of hesitation that I refer to this species, a very small pentagonal star-fish, collected while dredging on muddy bottom in about ten feet of water, in the East Harbor at Port Antonio. When living, the flat abactinal surface was dark olive green and the actinal surface almost white, but alcohol has entirely destroyed the color. The size is much less, but the proportions about the same as in Perrier's type of *parvus*, and the number of marginal plates is the same.

$$R = 5\frac{1}{2} \text{ mm. } r = 3\frac{3}{4} \text{ mm. Mar. pl. } \begin{matrix} 9-10 \\ 8-10 \end{matrix}$$

The marginal plates are large and thickly covered with granules. The adambulacral plates carry four blunt spines on their free margins and one prominent spine on the actinal surface. The abactinal surface is very granular. Although the identification of this little asteroid is not entirely satisfactory, I do not feel inclined to base a new species on a single small specimen.

Family: Pentacerotidae.

8. *Pentaceros reticulatus* (L.).

This familiar West Indian star-fish may be readily distinguished by its size, shape and color. It is decidedly pentagonal, though the rays are evident and the abactinal surface

is highly arched and covered with knobs and tubercles. The color is orange red of some shade, often becoming brown in dried specimens. It is the largest of the Jamaican Asteroids, and some individuals reach a diameter of 500 mm., while 300 mm. is a common size. Plentiful in Kingston Harbor, but rather rare at Port Antonio. Only two specimens were seen there, and those were on muddy bottom in East Harbor.

Family: Asterinidae.

Asterina.

The Jamaican species of this genus may be recognized by their small size, distinctly pentagonal shape, and the presence of spines on the interradial plates of the actinal surface. This little star-fish occurs on the under side of the rocks about the reefs, but so closely do they cling, and their coloration harmonizes so with their surroundings, they might easily be overlooked.

9. *A. folium* (Lüt.).

Distinguished by the proportions and arrangement of the spines.

$$R = 8 \text{ mm. } r = 7. \therefore r = .875 R, \text{ or} \\ R = 6\frac{1}{2} \text{ mm. } r = 6. \therefore r = .923 R.$$

Adambulacral plates with 4-5 spines on the free margin and 3 on the actinal surface; interradial plates with 3-4 spines on each; and inferior marginals with numerous fine spines on the outer edge. My largest specimen is 18 mm. across. The color of this species varies greatly, the commonest shades being blue, reddish yellow, green and almost white. Common on the broken slabs of coral rock at Drunkenman Cay, and also found at Rackum Cay. On the north side of the island, the only specimen seen was collected at Port Antonio.

10. *A. minuta* (Gray).

Specimens of this star-fish are easily separated from the preceding by their smaller size, less distinctly pentagonal shape, and the arrangement of the spines. My largest specimen is only 12 mm. across.

$$R = 5 \text{ mm. } r = 4. \therefore r = .800 R.$$

Adambulacral plates with 2-3 spines on the free margin and 2 on the actinal surface; interradial plates with only a single spine (rarely 2), and inferior marginals with a single series of about 10 rather long spines on their outer edge. Color almost white, with little variation. Very common on the Fort Reef at Port Antonio and on other reefs about that harbor, but no specimens were taken on the south side of the island.

There can be no doubt, I think, that Sladen (*Challenger Reports*, Vol. XXX, page 393) is right in rejecting Perrier's conclusion (*Arch. de Zool. Exp.*, Vol. V, 1876, page 229) that *folium* is a synonym of *minuta*. I can find no evidence of any intergradations between the two species, my smallest specimens of *folium* showing all the characters of that species. It is interesting to note also that *minuta* seems to characterize the north-side fauna, while *folium* is much more distinctive of the south side of the island.

11. *Stegaster vasseli* (Per.).

Another pentagonal star-fish occurs on the reefs at Port Antonio, though I did not see it elsewhere. It is readily distinguished from either of the preceding by being covered with a thick and very granular skin. The adambulacral plates bear 3 spines on their free edge and the oval plates bear 5 or 6 closely crowded long spines, but these are all hidden by the margin of skin which overlaps the mouth and ambulacral furrows. The interradial plates in large specimens bear 4 or 5 distinct spines, somewhat hidden by the thickness of the skin, but in smaller specimens these could not be detected. Inferior marginal plates bear numerous very short, sharp spines on their outer edge. In shape this species is much more highly arched than either of the preceding. The largest specimen taken was 35 mm. across and 7 mm. high. $R = 20$, $r = 18$, $\therefore r = .900 R$. A number of specimens of this star-fish were collected on the Fort Reef at Port Antonio in company with *Asterina*, *Ophidiaster* and *Linckia*. I am indebted to Professor A. E. Verrill for the identification of this species, my specimens of which do not wholly agree with Perrier's original description.

Order: Cryptozonia.

Family: Linckiadae.

12. *Ophidiaster guildingii* (Gray).

Rays rather long and almost cylindrical. Papulae arranged in group in regular longitudinal rows on the upper side of the annus. Color varies from orange red, with irregular yellow markings, to purplish brown, with blotches of dirty white. Size usually rather small, 60-70 mm. across; rays 25-30 mm. long. Not seen on the south side of the island, but fairly common on the Fort Reef at Port Antonio, occurring in crevices in the coral rock. All the specimens taken have five perfect and approximately equal rays.

13. *Linckia guildingii* (Gray).

Rays somewhat more flattened than in *Ophidiaster*. Papulae in groups, scattered irregularly all over the abactinal surface. Color of large specimens bright yellowish brown, but smaller specimens are darker, almost a chocolate brown, with a shade of purplish; rarely blotched with a lighter shade. Size usually medium, but one specimen was found 200-250 mm. across. Occurs rarely among the corals on the south side, but is quite common at Port Antonio in the crevices of the reef and broken rock. Rays, sometimes 5, but often 6, and very rarely equally or symmetrically developed. A number of specimens were collected showing the disc and four small rays growing out from the end of a large ray, and sometimes single rays were found alive and moving, with no signs of a recent separation from the disc.

Family: Echinasteridae.

14. *Echinaster spinosus* (Retz.).

Easily recognized by the bright red color and the spiny projections on the abactinal surface. Size medium, about 160 mm. across, with rays 65 mm. long. Found on muddy bottoms among the mangroves. Very common at Port Royal, and seen at Montego Bay, but none were found at Port Antonio.

AMHERST COLLEGE, January, 1898.

Embryology of *Ophiocoma echinata*, Agassiz. Preliminary Note. By C. GRAVE.

The conflicting results of previous investigators, and the need of confirmation of some of the results obtained by them upon ophiurid development seemed to warrant my undertaking a new investigation of the subject, and by the advice of Prof. W. K. Brooks it was made my principal object while in Jamaica during the Summer of 1897, to obtain a series of embryological material extending at least from the segmentation stages to the beginning of metamorphosis.

But when I arrived at Port Antonio on June 14th, I found that in no species at hand had the breeding season begun except with *Ophiocoma Riisei* with which it was over, and it was not until less than three weeks of the end of my stay that the first ripe eggs were thrown by *Ophiocoma echinata* although ripe spermatozoa had been obtained every day for more than a month.

In consequence of this the oldest plutei reared were but sixteen days old and showed no signs of metamorphosis, but probably had reached their adult form and size.

The eggs, which were of an orange red color, after being fertilized threw about themselves a tough prickly egg membrane which rendered preservation difficult until it was burst and the larva had escaped.

At first the points and ridges of this glutinous egg membrane were quite high and regular, but soon were worn down and became as shown in Figure 1. Under the outer egg membrane is still another, very thin and closely applied to the developing larva.

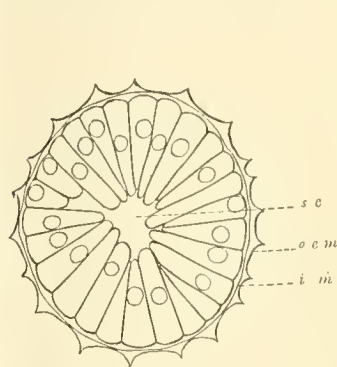


FIG. 1.

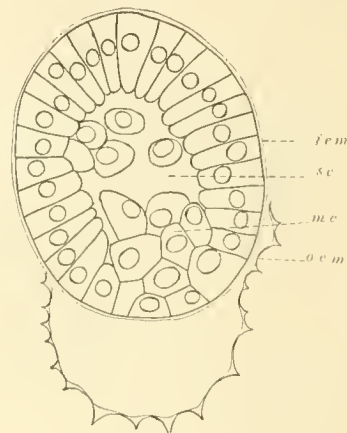


FIG. 2.

Segmentation was regular and a blastula was formed, consisting of cells of equal size or nearly so, and with a very small segmentation cavity. The long cylindrical cells composing its walls before dividing flatten down and become as nearly spherical as conditions will admit, as has been described by Korschelt for sea urchins and as is shown for *O. echinata* in Figure 1, which is a camera sketch of a section of a blastula. The growing larva now bursts the chitinous membrane which encloses it, crawls out and swims about in the water. It is somewhat elongated and swims in the direction of the axis connecting the animal and vegetable poles, the animal pole, which is slightly pointed, preceding.

As it moves from place to place, it is continually revolving on the long axis. At the time of hatching, the mesenchyme formation has just begun. It takes place by the rapid proliferation of cells at the vegetable pole, no evidence being found of its originating as two bands, and is continued until the segmentation cavity is quite crowded with cells. Figure 2, is a camera sketch of a section of a larva at the time of hatching, cutting it in the plane of the long axis, showing the shape of the larva at this stage and the method of mesenchyme formation.

The cilia did not show in the section, but those at the animal pole are much longer than those over the rest of the larva.

The gastrula stage is formed several hours later by the invagination of the vegetable pole. The cells composing the invaginated tube or archenteron are all of about the same shape and size, but a decided differentiation is to be noted among the ectoderm cells. Those at the animal pole are much elongated and vacuolated thus forming a thickened apical plate. The

lateral walls too have each a thickened area, while the cells of the ventral side are of a uniform thickness, but much thicker than those composing the dorsal surface of the larva which are much flattened and thin. Near the thickened lateral areas, clumps of mesenchyme cells collect and begin to secrete the larval skeleton. Beside these, other mesenchyme cells take up the function, probably, of support for the archenteron and other organs as they form. At least in gastrulae and older larvae, long branching cells can be seen in the segmentation cavity connecting the archenteron with the ectoderm wall, or with other mesenchyme cells, or connecting two portions of the ectoderm. The cells of the supported parts to which the processes of the mesenchyme cells attach, take an active part in the formation of the connecting fiber, or strand, as part of their substance meets and fuses with that sent out by the mesenchyme cell.

From the apex of the flattened archenteron a pair of pouches grow out and are constricted off, one to the right the other to the left. Each of these divide into two pouches of about equal size, one of which remains in about its original position while the other migrates toward the blastophore and takes up a position on the side of that part of the archenteron which will later become the stomach. This is as Metschnikoff described it, and as Bury supposed must be the case, but contrary to what both the above investigators describe, I find that the right posterior pouch degenerates and disappears, thus leaving a larva with a pouch on either side of the oesophagus and one on the left side of the stomach. This condition was noted in every pluteus observed, and hundreds of them have been studied.

In confirmation of the phenomenon observed in ophiurans by Metschnikoff, and in starfish larvae by Brooks and Field, I find that soon after their formation, the two anterior pouches both communicate with the exterior through pore canals which open on the dorsal surface of the larva.

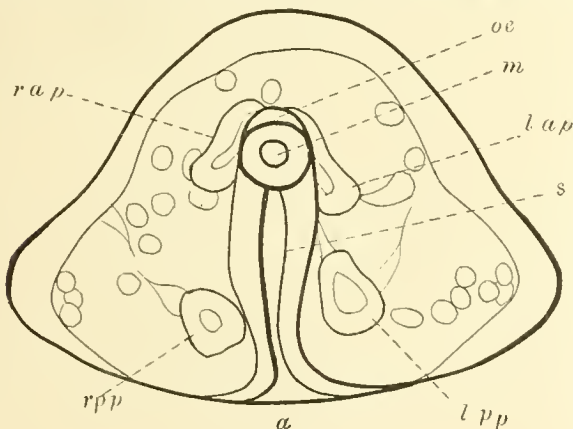


FIG. 3.

At about the time of the formation of the pore canals or a little before, the larval mouth breaks through on the ventral surface and there is formed the perfect bilaterally symmetrical larva shown in Fig. 3, which is the optical section of a larva lying on its dorsal surface, the outlines having been made with a camera lucida.

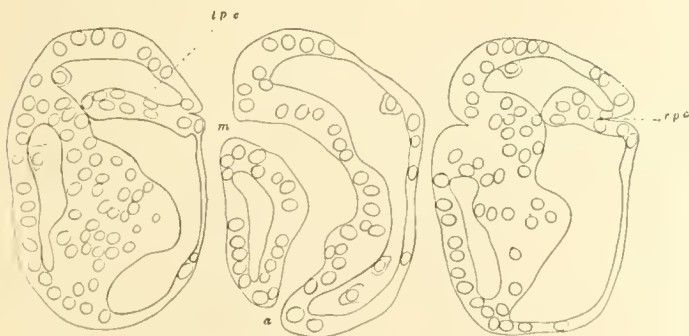


FIG. 4.

The pore canals are not, as Bury describes, intracellular structures but consist in an epithelium of flattened cells as is shown by Figs. 4, and 5, which are camera drawings of sections of two larvae. Fig. 4, represents

the 17th, 21st, and 24th longitudinal sections of a young larva, the 17th section passing through the edge of the alimentary canal and left pore canal, the 21st being the median sagittal section and passing through the mouth and anus, the 24th cutting the larva in the plane of the right pore canal. Fig. 5, is a transverse section through the oesophagus of a slightly older larva cutting both pore canal openings.

The abundance of apparently normal larvae having two pore canals indicates that it is a normal condition of larvae of that stage, which, should it so prove to be, would probably constitute a character of some phylogenetic importance. The right pore canal sooner or later disappears, but persists slightly longer than the right posterior pouch which is very transient in its character.

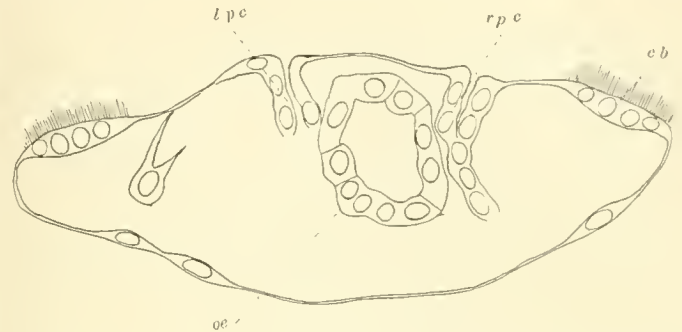


FIG. 5.

With the exception of the arms, which become very long, and the skeleton, which has been dissolved out, the pluteus, after undergoing the above transformations, appears as shown in Fig. 6, which is the optical section of a young pluteus made in the same manner as Fig. 3, but in this case the pluteus is lying on its ventral surface.

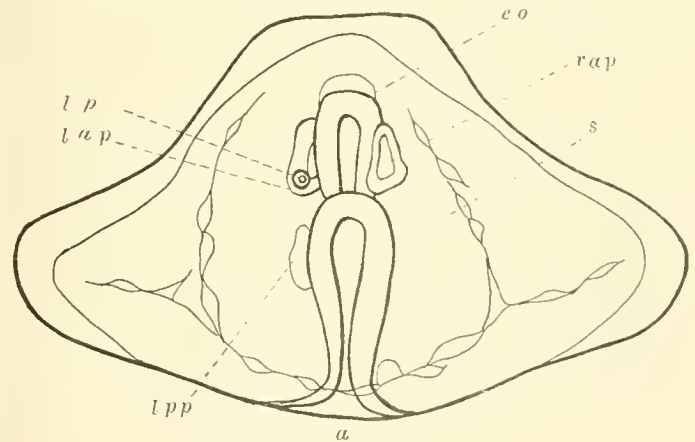


FIG. 6.

EXPLANATION OF LETTERS IN FIGURES.

- | | |
|----------------------------|-----------------------------|
| A.—Anus. | Oe.—Oesophagus. |
| Cb.—Ciliated band. | Oem.—Outer egg membrane. |
| Iem.—Inner egg membrane. | Rap.—Right anterior pouch. |
| Lap.—Left anterior pouch. | Rpp.—Right posterior pouch. |
| Lpc.—Left pore canal. | Rpc.—Right pore canal. |
| Lpp.—Left posterior pouch. | S.—Stomach. |
| M.—Mouth. | Sc.—Segmentation Cavity. |
| Me.—Mesenchyme. | |

Notes on the Ophiurids collected in Jamaica during June and July, 1897. By CASWELL GRAVE.

During the summer of 1897, while I was working at the Johns Hopkins Biological Laboratory stationed in Port Antonio, Jamaica, I improved the opportunity of collecting the Ophiurids found in that locality.

Up to the present time five species only have been noted from the island, and these from Port Henderson, on the south side. One of the just mentioned list, *Ophiocoma aethiops*, does not occur as described, but *O.*

echinata is very abundant in that locality and probably is the species referred to as *aethiops*.

No attempt at detailed descriptions is made in this note, but only the habitat and such general characters of each species are given as will aid students in finding and identifying the specimens at the seashore.

The numbers immediately following the name of each species refer to the pages in Theodore Lyman's works on Ophiurids where a detailed description of the species in question will be found or a reference to such a description. The first numbers refer to the Challenger Report, the second to Part I of the Illustrated Catalogue of the Museum of Comparative Zoology of Harvard College for 1865.

I. *Ophiocoma*, Agas.

This genus is characterized by a granular disk; covered radial shields; the possession of both tooth and mouth papillae, the former being numerous and arranged in a vertical clump; arm spines smooth, solid and rather stout, 4-6 in number; two genital openings in each interbrachial space.

1. *Ophiocoma echinata*, Agas. 167-169, 81-83. This is the largest brittle star found in Jamaica, measuring 3.2 cm. across the disk. It occurs everywhere, but is especially abundant on the shallow reefs under loose stones, which afford it a hiding place during the day. The small young specimens are most plentifully found by tearing up the calcareous algae which grow on the reefs. The general color of the species is grayish; the disk, however, varies much in its markings, a dark star in its center being quite common. The arms are spiny and usually banded with dark. The breeding season begins toward the end of July.

2. *Ophiocoma Risei*, Ltk. 167, 76-77. Found with No. 1, with which it agrees in size and form. The general color is black above, but the reddish orange foot tentacles give the under side a reddish appearance. It breeds early, probably in April and May.

3. *Ophiocoma pumilla*, Ltk. 168-171, —, —. Found also with No. 1. Medium in size, 1.2 cm. across disk; very long, slender, spiny arms, which are banded with dark, the general color of the species being a light brownish yellow. In June and July, when examined, the gonads were small and immature.

II. *Ophiura*, Lmk.

The disk in this genus is also granular, but the granulations are much smaller than in *Ophiocoma*; mouth papillae numerous; arm spines 7-13 to each side of each joint, smooth and shorter than the arm joints; four genital openings to each interbrachial space.

4. *Ophiura appressa*, Say. 8-9, 34-35. Found under the same stones with No. 1. Medium in size, the average diameter of the disk being 1.4 cm. General color brown, variegated with green, red and white. Arms round, banded with dark; 8-9 very small spines on the side of each vertebra, the lowest of which are longest. During July the eggs were large and much pigmented, probably breeding in August.

5. *Ophiura brevicauda*, Lyman. 8-9, 16-18. Found with No. 1. Average diameter of disk, 1.4 cm. Color greenish, variegated with white and brown. The specimens keep their color well in alcohol. The arms are much stouter than in No. 4, and the 8-10 arm spines are short, stout and equal in length.

6. *Ophiura guttata*, Lyman. 8-9, 10-20. Slightly larger than No. 4, with which it is found. This species is easy to recognize by the bright yellow under surface of the arms. The upper surface of the arms and disk are dark. The 9-10 arm spines are slender and equal in length.

7. *Ophiura brevispina*, Say. 8-9, 16-19. Same size as No. 4, and difficult to distinguish from it, both being found together. The 7-8 arm spines are equal in length, and the color is a little more greenish than in No. 4.

III. *Ophioneris*, Ltk.

Disk covered with fine overlapping scales, which nearly cover the radial shields; 3-5 smooth arm spines on either side of each vertebra; a supplementary piece on each side of each upper arm plate; two genital openings in each interbrachial space.

8. *Ophioneris reticulata*, Stk. 160-162, 140-142. About the same size, color and form as No. 3, with which it is found, but easily distinguished from it by the disks being reticulated with small dark lines. Gonads immature in June and July.

IV. *Ophiolepis*, Müll and Trosch.

Disk covered with radial shields and stout plates, each larger one being surrounded by a row of small ones; arm spines short and small, supplementary pieces to upper arm plates; two genital openings in each interbrachial space.

9. *Ophiolepis paucispina*, Müll and Trosch. 18-20, 55-57. Found by tearing in pieces the calcareous algae which grow on the Fort Reef. Its color is the same as the light-colored sand and algae on which it lives. This is a very small species, the disk seldom exceeding .5 cm. in diameter. The arms are short and round. Gonads immature in June and July.

10. *Ophiolepis elegans*, Ltk. 18-19, 55-59. Diameter of disk, 1.2 cm. Under surface pure white and covered with large irregular plates. A beautiful Ophiurid, and found quite plentifully by dredging the West Channel of West Harbor. Sexually immature when examined in June and July.

11. *Ophiolepis impressa*, Ltk. 18-19, 55. The average diameter of the disk of this species is 1 cm. Distinguished from No. 10 by being smaller and found in shallow water. Arms regularly banded. Sexually immature when examined in June and July.

V. *Ophiotrix*, Müll and Trosch.

Disk set with thorny grains and spines set with thorns either at the top or on the sides; radial shields are large triangular swellings; numerous tooth papillae, but no mouth papillae; arm spines longer than the joints, 5-10 in number, flattened and glassy, having a central shaft; interbrachial spaces swelled out like lobes, each of which has two genital openings beginning outside the mouth shields.

12. *Ophiotrix Oerstedii*, Ltk. 213-226, 153-156. Disk 1.2 cm. in diameter. Bulging between the arms. Deep green in color, but opposite each arm is a yellow line, bordered on each side by two black lines, reaching almost to the center of the disk. The arms and disk are covered with long spines. Two specimens dredged from East Harbor and one taken from under stones on Fort Reef. The most common species at Port Henderson.

VI. *Amphiura*, Fbs.

Disk small and delicate, covered with naked overlapping scales; radial shields uncovered; no tooth papillae and few mouth papillae; arms long and slender; spines short and regular; two genital openings in each interbrachial space.

13. *Amphiura Palmerii*, Lyman. 123-143. Diameter of the disk, 9 cm. Arms very long and spiny. Light yellow in color. Upper side of disk covered with short spines, except in five naked areas opposite the bases of the arms, where the radial shields are exposed. Three specimens dredged off Folly Point and East Harbor.

VII. ———.

14. —, —. Two specimens of an Ophiuran were taken with the dredge from East Harbor which were of a light green color and with a disk diameter of .6 cm.; six arms, which were short and furnished with very short, blunt spines or knobs. No plates could be made out except about the mouth.

The Development of *Pilularia globulifera* L. By DUNCAN S. JOHNSON.

(Abstract of a paper published in the *Botanical Gazette*, July, 1898.)

The following abstract gives some of the results gained from a study of the development of the leaf and sporocarp in *Pilularia*, which has been carried on by the writer in the biological laboratory of this university, while holding the Adam T. Bruce Fellowship for the year 1897-98.

The leaf of *Pilularia*, like that of *Marsilia* and many other leptosporangiate Ferns, develops from a two-sided apical cell. The number of primary divisions in each segment of the eleven or more pairs formed from this is four, instead of six as in *Marsilia*. All of these divisions take part in the formation of each of the three meristem layers. An epidermis and a hypodermis, each of a single layer, are developed from the protoderm, and in the former of these are developed stomata and trichomes. From the ground-

meristem are formed the single layer of mesophyll and the partitions separating the ten air canals of the leaf. The procambium gives rise to the vascular bundle together with its sheath, which therefore does not come from the surrounding ground-meristem as usual. No indication of any rudiment of a lamina was discovered by a careful study of the mode of division of the segments at the tip of the leaf.

The sporocarp arises by the formation of a two-sided apical cell in one of the anterior marginal cells of the leaf near its base. Six or more segments are cut off from each side of this, which have seven primary divisions formed in each, exactly as in *Marsilia*. In the segments forming the stalk of the sporocarp, which do not always form seven primary divisions, the formation of tissues from the three meristem layers is similar to that in the leaf, except that the ventral part of the procambium gives rise to a bundle of sclerenchyma tissue.

In the terminal segments of the sporocarp, forming the capsule, two of the ultimate marginal cells on each side one for each sori, are devoted to the formation of sporangia. These sporangial marginal cells divide, in a more irregular manner than in *Marsilia*, to form the sporangium-mother cells, and these are in the meantime overgrown and enclosed in the soral canals by the other cells of the ventral side of the capsule. The sori are thus in a right and a left pair and are lateral in position at first, none being terminal as described by Meunier and Campbell. Later on, by the more rapid growth at the base of the capsule on the ventral side, the openings of the soral canals are pushed around to a nearly terminal position.

The macrosporangia and microsporangia are not derived from different marginal cells as in *Marsilia*, but the two are indistinguishable up to the time of the formation of the spore-mothercells.

The axial vascular bundle, entering the capsule at the base, gives off soon a branch toward the left and another toward the right, each of which furnishes the six branches of the two valves on its side of the capsule, together with the placental bundle and placental branch arising from the middle bundle of each valve. The three main bundles of each sorus fuse together against tip of the valve, but there is no fusion of bundles from different sori as in *Marsilia*.

The firm wall of the capsule of *Pilularia* consists of an epidermis of thick brown walled cells, an outer hypodermis of thick clear walled prismatic cells and an inner hypodermis of more irregular brown walled cells. Across the base of the capsule is formed the basal wall, one layer of which is exactly like the outer hypodermis and continuous with it, having the same characteristic "light line." Near the dorsal side of the capsule there is a slit through this wall, corresponding to the air passage opening into the lens-shaped space of *Marsilia*, but the loose tissue near this slit in *Pilularia* is not cut off from the rest of the capsule. A projection, corresponding to the lower tooth of the capsule of *Marsilia*, is present in *Pilularia* and a depression or pit is formed just above this, but no upper tooth is present.

The outgrowth of the cells of the ventral side of the capsule gives rise not only to the wall surrounding all the sori, but also to the indusium which separates the individual sori from each other. The mode of development of this tissue seems to warrant calling it an indusium, as was held by Mennier.

Of course the whole question of homology is here greatly complicated by the fact that the *Marsiliaceae* seem to bear the sporangia on the upper side of the leaf. But the transition from a form like *Lygodium*, with single sporangia developed from marginal cells of the leaf, to the present forms where the marginal cell may give rise to several sporangia does not seem perhaps so very abrupt.

The capsule of *Pilularia* then is essentially a *Marsilia* capsule with only two pairs of sori, and both are to be considered as branches of the leaf in which, instead of forming a lamina, the marginal cells have been devoted to the formation of sporangia. Of the two genera, the evidence at hand indicates that *Marsilia* is more nearly related to the other *Leptosporangiatæ*.

Dr. F. S. Conant's Notes on the Physiology of the Medusae. By E. W. BERGER.

While in Jamaica with the Johns Hopkins Marine Laboratory, during the summers of 1896 and 1897, Dr. Conant preserved material and made many observations and experiments upon the medusae. His systematic, morphological and histological results have since been published as his

thesis by the University, while his notes on the physiology, together with other results from the material preserved by him, remain.

It is intended in the following paragraphs to note briefly only the results obtained and to leave the notes themselves, together with a fuller discussion, for a more complete paper. Since, however, the notes were left almost wholly undigested, some attempts at generalization will here and there be made.

The forms used in these observations were *Charybdea xaymacana*, one of the two species first found and described by Dr. Conant, *Aurelia aurita* and *Polyclonia*. The greater number of these notes are on *Charybdea* and were left just as taken at the time of experimenting. Many of these notes are highly interesting and in the main fit in well with Romanes' results.

It was at the request of Dr. Brooks, soon after the unfortunate death of Dr. Conant, that the present writer has undertaken to make use of his notes and other medusan material.

For the anatomy of *Charybdea* see the November (1897) number of the *Johns Hopkins University Circulars* or Dr. Conant's thesis, "The Cubomedusae," both published by the Johns Hopkins Press.

Light.

A part of Dr. Conant's experiments were performed in a photographic dark room with the animals in a deep glass aquarium jar. In the dark a fair proportion of the animals became nearly quiescent on the bottom, but upon lighting a lamp many started up immediately, while others took a longer time to come to the surface and swim. Such experiments were tried a number of times and on different occasions with very similar results. Some, however, tried immediately after being brought in, seemed not to react so well upon being placed in the dark room, nor would they become quiescent. This probably was due to the fact that the animals had not yet recovered from the effects of being caught and placed in new surroundings.

Other experiments were tried by carrying the jar with the animals from the weaker light of a room into the more intense light of outdoors or into direct sunlight. The usual result was an inhibition of pulsation and a settling to the bottom, while they immediately became active again upon returning with them to the room. These results were so marked that no doubt can be entertained as to their cause, though some exceptions occurred in which animals placed in the sun continued to swim on the surface or soon recovered pulsation. In some experiments, too, no animals responded to the stimulus of the brighter light or all very soon recovered.

Reducing the light by placing a coat over the jar produced the same effect in some experiments as reducing the light in other ways, while removing the coat produced the same effect as exposure to brighter light. It is, of course, to be noted, too, that when left for some time in any one place the animals changed, some coming to the surface and others going to the bottom.

Such experiments as indicated above show beyond doubt that *Charybdea* is sensitive to light and that it is moderate light which stimulates the animals to activity, while darkness and strong light inhibit such activity. While the individual exceptions, as Conant himself suggests, are well explained on the supposition of individual differences, yet it appears that other conditions, such as the time of day, temperature, etc., may have been responsible for the exceptional experiments in which no animals responded as expected.

Also, what may have been appreciable light to one animal was less such to another or quite strong light to a third.

While light of any intensity seems to have stimulated Romanes' *Sarsia* and *Tiaropsis* to activity, we note that it is moderate light which stimulates *Charybdea*. This is evidently correlated with the fact that *Charybdea* is chiefly a bottom-living form.

Were one to conclude from the behavior of *Charybdea* in light and darkness in the laboratory that it remained on the bottom in the day-time, but became more active near the surface evenings and early mornings, one would probably not be far from the truth. Dr. Conant in towing near the bottom with a weighted net, in water four to five feet deep not far from shore and deeper farther out, found *Charybdea* in abundance mornings and afternoons, but very few in the evening. In the evening some were usually taken in the surface tow.

Finally, while I find no experimental evidence in Dr. Conant's notes about what parts of *Charybdea* are sensitive to light, it would seem preposterous, from histological evidence, to doubt that the eyes of the four marginal bodies are the seat of this stimulation.

Dr. Conant further experimented by cutting off certain organs or parts from the Cubomedusan bell. These excisions consisted chiefly in cutting out the concretions of the sensory clubs, cutting off the whole club, eliminating a part or whole of the margin or velarium, cutting the bell in sectors, excising the stomach, and parts connected with it, and other parts. The remainder of this paper will be given to briefly stating the results of these operations.

Concretions.

The four concretions were removed from each of four animals. Two of these (1 and 2) seemed to be little if at all effected by the operation. One (1) swam actively, at first up and down more changeably than those intact, but later mostly near the surface. The other one (2) also swam actively and showed nothing to indicate weakened sense-perception. The other two (3 and 4) did not stand the operation well, as Conant states, and immediately went to the bottom where they remained, one swimming, while eight hours later one was still in good condition.

Several attempts with stronger light by removing the coat from the jar made no difference in the behavior of 1; it continued to swim as heretofore. Upon a final trial, however, with removing the coat, it went to the bottom, thus showing a sensibility to light; but when next seen it was keeping to the bottom.

We can hardly suppose that the concretions function as organs of light sensation as the first of the above animals would seem to indicate, for the animal evidently later reacted normally to light. The fact, too, that this same animal (1), together with another (2), swam actively, immediately changing their course upon coming to the surface, in reality behaving quite as normal animals, hardly permits us to conclude from the behavior of 3 and 4 that the concretions function directly as organs of equilibrium or space relations. Might not these concretions function simply as weights for keeping the sensory clubs with their eyes properly suspended? Since these concretions lie at the lowermost part of the clubs and in closed sacs and unsupported by cilia, it would seem that the above suggestion as to their being weights is not so improbable. Direct observation by Conant shows, furthermore, that the clubs always hang with a tendency for the concretions to be lowermost regardless of the position of the animal.

Sensory Clubs.

The entire sensory clubs were removed from a number of animals. A paralysis of pulsation followed by a rapid recovery was the usual result. In some instances, however, there was no paralysis while in others no recovery followed paralysis. This applies in a general way whether one club only or all were removed. Pieces of tissue with a club attached and pulsating regularly (See also Polyclonia) ceased pulsating after removal of the club, in one instance, however, still giving occasional contractions.

The paralysis following the removal of the clubs is evidently the effect of nervous shock, and points to the existence of some definite nervous mechanism in the clubs. The histological evidence is here, as usually, corroborative of the physiological.

While these results are the same in regard to shock as were obtained by Romanes upon *Aurelia aurita* after removing the lithocysts, they differ from his in the apparently complete recovery of pulsation. It may be added, too, that Conant succeeded in obtaining coördinated contractions on an *Aurelia*, found about Jamaica, after removal of all the lithocysts. (See *Aurelia*.)

Another interesting phenomenon observed after the removal of one or all of the sensory clubs was the strange behavior of the proboscis. This would reach from side to side expanding and contracting its lips as if trying to grasp something. This behavior is very similar to that of the proboscis of *Tiaropsis indicans* when Romanes stimulated any part of its subumbrella.

Velarium and Frenula.

"The power of originating contractions," to use Conant's own words, "evidently resides in the velarium or in ganglion cells of the frenula, just as it does in the proboscis and floor of the stomach." Isolated pieces of the velarium contracted by themselves as did the whole velarium when all other tissue had been removed. An isolated velarium with the margin and the pedalia attached gave irregular contractions. When the pedalia with the *interradial ganglia* were removed it still continued to contract; and when all the other tissue was cut off contractions still continued.

Cutting the velarium caused the *pedalia* to be strongly contracted inwards so that the tentacles were brought inside the bell. Cutting away the velarium did not interfere with the pulsations of the bell, but progress was much retarded.

Cutting the frenula caused the *pedalia* to contract but seemed not to effect the ability to swim.

Stomach, Suspensoria, Proboscis, Subumbrella.

The proboscis and the stomach with the phacelli when cut out contracted with or without the lips removed. The isolated lips also contracted (twitched).

Pieces of the sides connected only with the stomach and suspensoria or with the *margin* contracted (twitched) spontaneously, but seldom did so when these were removed. In one instance the whole side was cut out so as to exclude the radial ganglion, but still connected with a portion of the suspensorium. (See *Velarium*.) This pulsated, or contracted, but on being halved transversely the lower half ceased to contract while the upper half connected with the suspensorium continued to contract.

Cutting off the whole stomach end of the animal excited to very rapid pulsations of the remaining part with the stream of water stronger out the aboral end than past the velarium.

Dr. Conant says, "It seems I get no good evidence of the subumbrella without connection with any special nerve centres being able to contract by itself." The piece in which he did get contractions he suspects may have been intimately associated with some part of the frenula or the suspensoria. In Polyclonia no such doubt exists for small pieces of subumbrella were seen to contract. (See Polyclonia.) A small piece of subumbrella connected with a sensory club could contract by itself.

Margin, Radial Ganglia, Nerve.

Complete removal of the margin did not stop pulsation; but the removal of the radial ganglia stopped it permanently. While this experiment seems to have been tried only once, yet taking into consideration the results of other operations, it seems that the principal centres of spontaneity reside in these radial ganglia. (See also *margin* under stomach.)

In a Polyclonia paralysis of pulsation followed the removal of the margin but spontaneous contractions were observed some time after, showing a partial recovery. (See Polyclonia.)

Cutting the nerve in the eight *adradia* caused the *pedalia* to bend inwards at right angles to their normal position but did not in the least affect the coördination of the sides. When, however, the sides were cut in the eight *adradia* to the base of the stomach, coördination ceased and each side pulsated in its own rhythm.

Pedalia, Interradial Ganglia, Tentacles.

When the pedalia were removed the power of the animal to guide itself was completely gone. When one pedaliu was cut the others contracted, while stroking the outer edge of the pedalia, touching the sensory clubs or sharply pricking the subumbrella, often produced the same result. (See *Nerve*.)

When the pedalia were cut off far enough up to remove the *interradial ganglia* coördination was not effected and the animal could pulsate well enough but with little progress. (See also *Velarium*, *Frenula*.)

An isolated tentacle is capable of squirming contractions and when stimulated at either end it would contract wholly or in part only.

Temperature.

Ice in the water seemed to have no effect except when held against the animal when a slowing of pulsation followed in a few instances. On some pulsating actively in the sun the temperature of the water was found to be 92° F.

AURELIA AND POLYCLONIA.

Many of the observations on these forms relate to the rate of pulsation. In an *Aurelia*, following the removal of a lithocyst, there was a pause followed by pulsations. In about two minutes rhythmic pulsations were resumed. Four minutes after the operation there were nineteen pulsations to the half minute, while twenty minutes after there were only nine, and

these in groups of six and three. The normal rate of pulsation was twenty-five to the half minute.

Polyclonia behaved much in the same manner as Aurelia. Upon the removal of a lithocyst pulsations continued but in groups with short pauses. The normal rate of pulsation was twenty-seven to the half minute, while three minutes after the operation it was seventeen, and eleven minutes after fifteen to the half minute. The tissue connected with a removed lithocyst gave contractions.

The removal of a single oral arm or of the whole eight in Polyclonia had much the same effect as the removal of a lithocyst: there was a decided slowing of the rate of pulsation, while, however, the immediate effect was an acceleration or a return to the normal rate. About a day later this same animal had quite regained its normal rate of pulsation and continued to live for several weeks.

As already noted under *Sensory Clubs*, an Aurelia with all its lithocysts removed still gave spontaneous and coordinated contractions after allowing time for recovery from the operation. This was the result in one instance while in several others only a few contractions were observed. Removal of the sixteen marginal bodies in a Polyclonia produced paralysis for a while, but soon recovery followed.

A Polyclonia with its entire margin removed was paralyzed, but had so far recovered in a day as to be able at intervals to give spontaneous pulsations.

The removed margin of a Polyclonia pulsed vigorously. This margin was then split so as to make a ring within a ring but connected at one point by a small bridge of tissue. The waves of contraction, which always originated on the ring with the lithocysts, passed the bridge to the inner ring much the same as Romanes experienced. The outer ring was next split so as to separate the exumbrellal portion from the subumbrellal, when it was found that the contractions always originated from the latter.

Seven days after its removal this same margin was still alive and pulsating vigorously, and broken off pieces of the subumbrellal portion were pulsating by themselves. Fifteen of the ganglia were removed. It was then found that, while most of the pulsations originated at the remaining ganglion, now and then contractions originated in other parts where no ganglion remained. Two days later this margin was still alive with contractions originating as often from other parts as from the ganglion.

One with the eight lithocysts of one side removed, to compare with a normal one, gave no evidence of affected coordination.

An oral lobe from an Aurelia could give contractions some minutes after removal.

In another Aurelia a circular cut was made about the base of the oral lobes through the epithelium of the subumbrella. The animal could pulsate well enough but coordination seemed a little affected, while in another one with a like cut, but semicircular, no effect was noticed.

Note.—It is at present undetermined whether Conant had Polyclonia or Cassiopoea, or both, to work with. Since he mentions removing sixteen marginal bodies, it would seem that he had Cassiopoea; however, some specimens brought from Port Antonio, Jamaica, have only twelve marginal bodies and twenty-four radial canals, which is characteristic (according to Haeckel) of Polyclonia. At all events, Conant speaks of them as Polyclonia in his notes of 1896, and as Cassiopoea in 1897.

Notes on the Tentacles of *Nautilus pompilius*. By LAWRENCE E. GRIFFIN.

[The valuable material upon which these notes are based was presented to the Department of Animal Biology of the University of Minnesota by Mr. Louis Menage, and I am greatly indebted to Professor Nachtrieb for placing it at my disposal.]

The following notes on the structure and homologies of the tentacles of *Nautilus* describe points which have been of great interest to me and which seem important enough to justify publication preliminary to a complete account of the anatomy of the *Nautilus*.

All the tentacles of the *Nautilus* are built after a single plan, and preserve the essential features of this even when highly modified. Ordinarily the tentacle is considered to be formed by two parts—a fleshy sheath surrounding an extensile cirrus. The cirrus is the essential structure and will be spoken of as *the tentacle*, while the sheath seems to be merely a fold of the skin which has been produced around the cirrus for protective or sup-

portive purposes. Surrounding the head of the *Nautilus* are thirty-eight tentacles to which Owen gave the name of *digital tentacles*. The sheaths of these are fused to each other so that a complete *Cephalic Sheath* (Owen), open ventrally only, is formed. These tentacles have been described as having no regular arrangement, but an examination of fifty-one specimens proved that they are arranged upon each side in a constant order. Only six specimens showed a variation from the normal arrangement, and this variation existed in each case upon one side only. Whether the same tentacle always occupies the same position or not cannot be decided till after further dissection of the nerves going to the tentacles.

The digital tentacles present the structural plan uniformly and simply. The surface of the tentacle is marked by a close series of annular grooves, which are deepest upon the inner side of the tentacle. The tentacles are frequently flattened upon the inner side. A large nerve trunk occupies the center of the tentacle; around this are the radial bundles of longitudinal muscles. Closer examination of the nerve cord reveals that it is enlarged by collections of ganglion cells at regular intervals, each enlargement corresponding in position to a segment of the tentacle included between two of the annular grooves. From the ganglionic enlargements nerves pass to the different portions of the segment, but especially to the inner side. The segmental structure of the nerve cord persists in cases where all traces of the external annulations have disappeared.

Dr. Willey in a recent article, described the great adhesive power of the digital tentacles. This power seemed strange until after a closer study of the segments of the tentacles. The groove between the segments is much deeper upon the inner face of the tentacles than elsewhere. The inner face of the segment is flattened. On this side, between the epithelium and the longitudinal muscles, are radial transverse muscles; the only transverse muscles in the tentacles which we can surely identify as such.

Their operation would be somewhat as follows—when the flat surfaces of the segments of the tentacles are applied to any body a contraction of the radial muscles within each segment would pull the central portion away from the opposed surface and cause a vacuum to be formed between the segment and the surface. The adhesive power of any one segment must be slight; but there are from sixty to one hundred segments in each tentacle, half of which would probably be in a position to hold. And there are thirty-eight tentacles in the group. Thus the combined adhesive power of all the segments is very great.

It seems to me probable that we see here the beginnings of the suckers of the Dibranchiates. As these Cephalopods became more active and predatory, the simple sucker would naturally have been modified to form an organ better adapted to quick and sure seizing of the prey. Yet the principle of action is the same in the *Nautilus* and the Dibranchiates. It seems probable that the projecting portion of each segment of the tentacle formed a single sucker. Growth would cause these to take alternating positions. Possibly from each segment several suckers were formed by subdivision of the adhesive surface and the development of each portion into a sucker. These may have remained arranged in transverse rows, as in *Sepia* and other forms.

This theory of the formation of the suckers of the Dibranchiates necessitates our regarding the arms of the Dibranchiates as each corresponding to a single tentacle of the *Nautilus*, and not to groups of tentacles. The structure, arrangement and relations of the arms support the first view far more than the second. Comparison with the processes of change in other orders weakens the latter theory while strengthening the theory that a few tentacles gradually increased in size while the remainder were crowded aside and reduced.

The *ocular tentacles* present several differences of structure from the digital tentacles. Their sensitiveness is much greater. The greater depth of the annular grooves on the inner side is immediately noticed. Willey has found that the sides of the groove are ciliated. In some instances I find the cilia extending over the surface between the grooves.

Of internal structure, two points are especially remarkable. One is struck by the ease with which the tips of the ocular tentacles break off. This seems to be the result of a peculiar arrangement. In the plane of the annular groove the adjoining segments are separated by what in sections appears as a plain line along which the tissues are evidently weaker than elsewhere. In apparently normal cases there is no separation of the tissues, but the weak line appears sharply and distinctly. The line does not extend through the epidermis or the nerve cord. The lines are only found in the upper

portions of the tentacles. It is difficult to understand of what use this arrangement can be. The tips of the tentacles break off with exceeding ease, but can this be in any way advantageous to the Nautilus?

The other point is regarding the structure of the nerve trunk. There is here what I have termed an *accessory nerve trunk*. The usual nerve trunk is present having its layer of ganglionic cells around its periphery and its ganglionic enlargements in each segment of the tentacle. On the inner side of this, through nearly the entire length of the tentacle, runs a large nerve trunk, composed of several bundles of nerve fibres. The main nerve trunk and the accessory are closely united, but are easily distinguished by the layer of ganglion cells which surrounds the main trunk. There are very few, if any, ganglion cells in the accessory trunk. At the ends of the tentacle the accessory trunk gradually disappears; at the upper end by giving off nerves, chiefly to the inner side of the tentacle; at the base of the tentacle by gradual union with the main nerve trunk.

This accessory trunk has apparently been developed in connection with the remarkable sensitiveness of the ocular tentacles.

The nerves of the two ocular tentacles of each side are branches of a nerve which comes off from the pedal ganglion near the outer end, which also sends branches to the Hood.

The Hood consists of the fused and enormously enlarged sheaths of the dorsal digital tentacle of each side. The origin of the nerves of the ocular tentacles in the pedal ganglia and the fact that they form portions of nerves going to the sheaths of digital tentacles proves, as Dr. Willey has suggested, that the ocular tentacles cannot be considered as other than somewhat modified (and perhaps displaced) digital tentacles, and that they can in no wise be considered as the homologues of the optic tentacles and rhinophores of Gastropods.

There is in the female Nautilus, ventral to the buccal mass, a fleshy lobe which, dividing into two near its tip, bears upon each half ten to fourteen tentacles and, at the point of division, a rounded organ composed of a number of triangular lamellae. This lobe (the inferior labial lobe of Owen) is wanting in the male Nautilus; instead is found, nearly hidden beneath the buccal mass, a rounded organ which is named from its discoverer *Van der Hoeven's organ*. I think that anatomical evidence is strong enough to convince us that the inferior labial lobe and Van der Hoeven's organ are homologous organs.

There are about sixteen lamellae in the group in the center of the inferior labial lobe. The group is separated at the median line into two halves, the lamellae of each side facing each other. The largest lamellae are at the centre of the group, the smallest at the exterior. The lamellae are marked upon both surfaces by grooves parallel to their bases. A nerve showing some traces of ganglionic enlargements runs to the tip of each lamellae. The nerves of the lamellae of each half of the group unite. The trunk thus formed unites with the nerves of the tentacles of the lobe of its own side and the common trunk enters the pedal ganglion near the median line. The tentacles of each lobe are largest near the outer end of the series. They grow smaller and smaller as the median line is approached; those nearest the median line are frequently so small as to be scarcely visible. At this point it is possible to find a complete series of gradations between the lamellae of the median organ and the tentacles. The structure of the lamellae confirms the suspicion that they are modified tentacles. This homology has been suggested by Van der Hoeven.

Between the bases of each two lamellae is a pit lined by exceedingly slender epithelial cells. These cells are also from two to three times the height of ordinary epithelial cells. The cells bear cilia; apparently each cell bearing a single cilium, but the preservation of my material is not good enough for me to make sure of this point. Fine fibres appear to run from the bases of the cells into the tissues.

As has been said, Van der Hoeven's organ occupies the same place in the male that the inferior labial lobe occupies in the female. This organ is about one inch in length, three-quarters of an inch in breadth, and two-fifths of an inch in thickness. It is enveloped by a tunic which, over the anterior dorsal half, is free from the organ; thus allowing free communication between the interior of the organ and the exterior. The anterior half of the organ is separated into halves by a narrow vertical slit which leads into the central cavity. This is a low horizontal cavity extending from side to side.

At the anterior end, on each side of the opening, are a number of low, thick, vertical lamellae which quickly pass into thin, broad, shelf-like, horizontal lamellae which extend as far back as the posterior limit of the vertical slit-like opening of the organ. Back of this point the organ is gland-

ular; the glands completely surround the central cavity. The glands are typical examples of the compound-tubular type. The epithelial cells of both glands and lamellae are tall and cylindrical. The cells of the lamellae are for the most part heavily loaded with secretory products. The cells of the glands are also loaded. Yet the lumens of the glands as well as the central cavity are entirely free from secretion, this evidently being stored in the cells till needed for some unusual purpose.

Another kind of cell is found among the epithelial cells of both glands and lamellae. Around each epithelial cell are several fine hair-like sensory cells. The middle of each is swollen by the elongated oval nucleus. The tip of each cell is produced into a stiff sensory hair. The immense number of these cells bearing hairs makes the surface appear densely ciliated. The ordinary epithelial cells are of so much greater bulk than the sensory cells that close examination is required to reveal the fact that the cilia do not belong to them. I have seen the bases of the sensory cells continued for some distance into the sub-mucous tissue as fine fibres, of about the same diameter as the cell.

The nerves which innervate Van der Hoeven's organ have the same place of origin as those which innervate the inferior labial lobes of the female. One nerve enters each side of Van der Hoeven's organ and divides into a large number of branches. One of these runs into each lamella and several supply the glandular portion of the organ.

The number of lamellae of Van der Hoeven's organ closely corresponds to the number of tentacles plus lamellae of the inferior labial lobe. The innervation is the same in each, except that the nerve seems to form all its branches at one point in Van der Hoeven's organ instead of at two points as in the labial lobe. The musculature of the one is the same as of the other. Willey finds that the same arteries supply both organs, and upon this fact bases the suggestion that they may be homologous. The sensory cells of Van der Hoeven's organ evidently correspond to those found between the bases of the lamellae on the labial lobe. Only, in the one case they are restricted to definite areas while in the other they are scattered throughout the organ. In short, anatomical evidence admits of no conclusion but that Van der Hoeven's organ of the male Nautilus is strictly homologous with the inferior labial lobe of the female Nautilus.

From the fact that the glandular cells in my sections of Van der Hoeven's organ are nearly all heavily loaded and that absolutely no secretion is present in the lumens of the glands or in the central cavity of the organ, it appears that its glandular function may be limited to certain times and conditions, possibly connected with reproductive processes. The sensory function is probably the same in both sexes, and continually active. Though it is possible that this also may be closely connected with reproduction.

The structure of the Hectocotylus (or Spadix) has recently been admirably described by Vayssi re. Still, there are several points which may be added to his description.

The Hectocotylus is composed of a group of four tentacles. These become highly modified. The organ is usually situated upon the left side; but in between twenty and twenty-five per cent. of my specimens it is upon the right side. In one case Hectocotyls are upon both sides. On the opposite side of the animal from the Hectocotylus is a similar group of four tentacles, but unmodified.

Three of the tentacles forming the Hectocotylus are closely enveloped by a fleshy sheath; the fourth and smallest only partly. On the external side of the sheath, at the margin, is a circular glandular area. The glands are compound-tubular, branched quite simply. They extend, in a direction perpendicular to the surface, about three-quarters of the distance through the sheath. Upon examining the corresponding portion of the sheath of the similar group of the opposite side I found a glandular area in the same position as that upon the sheath of the Hectocotylus. The area is smaller, the glands are less developed, yet are exactly similar in structure. The presence of this gland on both groups of tentacles is extremely interesting, as it may indicate an original hectocotylization of both groups.

In the second tentacle of the Hectocotylus (the tenth cirrus of Vayssi re) is another interesting series of glands. This tentacle is annulated, the grooves being deepest upon the upper side. Into each groove, upon this side, opens a row of perfectly simple sac-like glands. The openings are exceedingly small and are well hidden in the depths of the grooves. A single layer of columnar epithelial cells lines the gland. The cells of the neck of the gland are low, but they rapidly increase in height as they pass into the gland, so that the body of the gland is lined by exceedingly high cylindrical cells.

NOTES FROM THE GEOLOGICAL LABORATORY.

EDITED BY WILLIAM BULLOCK CLARK, PH. D.,

PROFESSOR OF ORGANIC GEOLOGY IN THE JOHNS HOPKINS UNIVERSITY.

REPORT CONCERNING THE OFFICIAL STATE BUREAUS
CONNECTED WITH THE JOHNS HOPKINS
UNIVERSITY.

TO THE PRESIDENT OF THE JOHNS HOPKINS UNIVERSITY:

I submit for your information the following report concerning the Maryland Geological Survey and the Maryland Weather Service during the past year. Much of the work of these bureaus is carried on in coöperation with the Geological Department and the offices are provided by the University free of all charges to the State.

THE MARYLAND GEOLOGICAL SURVEY.

The Maryland Geological Survey, which was established by the act of the General Assembly of 1896, began operations upon March 25 of that year, when, by the action of the Commission designated by the act, the organization of the Survey was formally effected. The General Assembly of 1898 passed two additional acts which added largely to the powers of the State Survey Commission by providing for the construction of topographic maps and the investigation of the question of proper highways for the State. By the first act an additional appropriation of \$5,000 annually was granted, while the second act appropriated \$10,000 annually, the original appropriation of \$10,000 annually by the Assembly of 1896 still remaining in force. By these acts the Survey received the very generous appropriation of \$25,000 annually.

During the two and a half years that the Survey has been in operation several lines of investigation have been taken up, some of which have already been carried to a conclusion. The preliminary survey of the State, in which general information in regard to the geology and economic resources was secured, placed the Survey in a position to inaugurate those lines of investigation which would prove most beneficial to the people of the State and at the same time would contribute most largely to the sum of knowledge regarding the stratigraphy and structure of Maryland. In connection with this general survey there has been maintained a system of collection of statistical data regarding the output of each industry that has to do with the mineral wealth of the State. Forms are annually placed in the hands of the producers of mineral products which upon their return are filed at the office of the Survey. In this manner an accurate account is kept of the mineral products of the State which aggregate in value from six to seven million dollars annually.

The work of the Survey has been systematically divided and a competent man placed in charge of each one of the divisions. Dr. E. B. Mathews, in addition to his duties as Assistant State Geologist, is Chief of the Division of Geology of the Piedmont Plateau; Professor Charles S. Prosser is in charge of the Division of Geology of the Appalachian Region, and Dr. George B. Shattuck is in charge of the Division of the Coastal Plain. The work of the Survey embraces many subjects related to geology among which is the investigation of our highways, Dr. H. F. Reid being Chief of the important Division of Highways. Dr. L. A. Bauer is in charge of the Division of Terrestrial Magnetism. Several special assistants in charge of independent lines of work are also employed: Mr. A. N. Johnson in Highway Engineering, Dr. Cleveland Abbe, Jr., in Physiography, and Messrs. Basil Sollers and B. W. Barton in Botany.

At the same time active co-operation is maintained with several of the Washington bureaus, especially with the U. S. Geological Survey and the bureaus and divisions of the U. S. Department of Agriculture. The aid which has been rendered by the Washington scientific departments has been of great importance to the successful prosecution of the State work.

The topographic work of the Survey has been much extended during the past year, an area of several hundred square miles having been surveyed upon a scale of one mile to an inch in western Alleghany and Garrett

Counties. The surveying force is provided by the U. S. Geological Survey through a plan of coöperation between the national bureau and the Maryland Geological Survey.

The magnetic work under the charge of Dr. Bauer was continued in the western portion of Maryland. Dr. Bauer completed his work on the western boundary of the State during 1897, and was able to be of great service to the Attorney-General of Maryland, who had the matter in charge. All of the magnetic and astronomical work was placed in charge of Dr. Bauer, and he was throughout recognized as the scientific authority upon the State force. During the summer of 1898 a part of Dr. Bauer's time was taken up in the survey of the boundary line between Alleghany and Garrett Counties, which had been authorized by a special act of the last General Assembly. This work, which had been many times unsuccessfully attempted, was satisfactorily accomplished, and a report published in September.

The more strictly geological work of the Survey was carried on by the instructors and students of the Geological Department of the University, with such coöperation as was deemed necessary along special lines. Professor George P. Merrill of the U. S. National Museum rendered the Survey a very important service in the conduct of the investigations upon the building and decorative stones of the State. Extensive areal and economic work was conducted both in the western and central counties of the State. Surveys of Alleghany and Garrett Counties were completed and a large amount of data collected for the special economic report which will appear later.

The highway investigations have occupied the attention of the Survey since the spring of the present year and a considerable force was employed under the direction of Dr. Reid and his associate Mr. Johnson in the study of the highway conditions of Maryland. The distribution of those rocks which are adapted for highway construction has been carefully surveyed and points for the subsequent locations of quarries of road metals indicated.

The agricultural conditions of the State have also been considered and a study made of many of the relations of the geological formations to the soils derived from them. This classification of the soils has been conducted under a plan of coöperation with Professor Milton Whitney of the U. S. Department of Agriculture and the Maryland Experiment Station, and outside of its scientific interest will prove of much practical benefit to the agricultural interests of the State.

The distribution of plant and animal life is so closely connected with the soils and geology that the Survey plans a study of the fauna and flora from this standpoint. Already some work has been done under the direction of Messrs. Sollers and Barton upon the botany of Maryland, more particularly in the western counties. It is planned in the future to carry on this work in coöperation with the newly organized State Horticultural Bureau.

Much advance was made during the year in the preparation of the manuscript for subsequent volumes. Professor Merrill completed his work upon the Building and Decorative Stones of Maryland and Mr. Henry Gannett of the U. S. Geological Survey furnished an elaborate treatise upon the Aims and Methods of Topographic work for the report upon the cartography of the State. These and other reports by the regular staff of the Survey are now being collected for the second volume which will be brought out during the autumn of 1898.

THE MARYLAND WEATHER SERVICE.

The Maryland Weather Service was established in May, 1891, under the joint auspices of the Johns Hopkins University, the Maryland Agricultural College, and the United States Weather Bureau, and became an official organization by an act of the General Assembly, approved by the Governor April 6, 1892. Under authority granted by this act the Maryland Weather Service was permanently established at the Johns Hopkins University,

under the direction of a Board of Control nominated by the heads of the institutions above mentioned and commissioned by the Governor.

During the first five years of the existence of the Service the investigations were confined largely to a study of the general meteorological conditions of the State. Numerous stations were established in the different counties, volunteer observers having been obtained at a sufficient number of points to render it possible to determine the more important features of the climate of the State. Throughout the same time monthly Meteorological Reports, extending through the year, and weekly Crop Bulletins, covering the growing and harvesting seasons, were published. Two biennial reports to the General Assemblies of 1894 and 1896 were also prepared and subsequently printed with the necessary maps, diagrams, and tables. A series of large Climatic Charts was also published and placed on exhibition in the Maryland Building in Chicago at the time of the Columbian Exposition, and copies of the same were subsequently distributed.

Somewhat over a year ago an entire reorganization of the work of the Maryland Weather Service was effected. It seemed desirable to transfer the accumulation of the general climatic data to the Climate and Crop Service of the Weather Bureau, which is much more fully equipped for carrying on that phase of the work, and to devote the money and energies of the Maryland Weather Service to the study of special problems connected with the climatology of the State. It was thought possible by conducting the work in close coöperation with the State Geological Survey, the State Agricultural institutions, and the U. S. Department of Agriculture to take up lines of research that would be of much permanent value to the people of the State. Arrangements were made for the publication of these investigations in a new series of reports which should conform in all particulars to those already adopted for the State Geological Survey. These volumes, for which arrangements have now been perfected, will contain the results of investigations upon the climate of the State and will include reports upon the physiography, meteorology, medical climatology, agricultural soils, forestry, hydrography, crop conditions, botany, and zoology of Maryland.

The reports upon physiography and meteorology are already largely prepared and will constitute the first volume of the series. Dr. Cleveland Abbe, Jr. has prepared a report upon the physiography while the longer and more elaborate statement regarding the meteorology of the State is divided into three parts, the general treatment of the subject being from the pen of the distinguished Professor Cleveland Abbe of the U. S. Weather Bureau; Mr. F. J. Walz the Local Forecast Official of the U. S. Weather Bureau in Baltimore and the Meteorologist of the State Weather Service will contribute the part relating to the meteorology of the State; while Mr. O. L. Fassig, his associate, will prepare those chapters which relate to the history of meteorological investigations in Maryland since early colonial days. The cordial support of Professor Willis L. Moore, Chief of the U. S. Weather Bureau, has been secured in this work as well as in many of the lines of special investigations which will be later pursued.

The investigations of the agricultural soils of the State, already referred to in connection with the State Geological Survey, are closely related to many of the climatological problems which will be considered in the future, and the active coöperation of Professor Whitney along these lines will add much to the effectiveness of the State work. Mr. C. W. Dorsey of the State Agricultural Experiment Station has been carrying on investigations in this field under the supervision of Professor Whitney and the results of their combined work will be later brought out in the reports of the State Weather Service.

The questions of hydrography are closely related to those of climatology and already considerable progress has been made in the study of the drainage basins of Maryland through the co-operation secured from Professor Newell in charge of the Division of Hydrography of the U. S. Geological Survey and special reports upon this subject will be incorporated in a later volume of the State Weather Service.

The other lines of investigations above referred to have been projected, but little work has been done upon them thus far. They will occupy the attention of the local Service during the coming and subsequent years.

WM. BULLOCK CLARK,

State Geologist and Director State Weather Service.

The First Geological Excursion along the Chesapeake in 1608. By EDWARD B. MATHEWS.

The first expedition for the purpose of investigating the natural resources of the territory now embraced in Maryland and Virginia was made during the summer of 1608 by Captain John Smith and his companions. Although the results are of little or no scientific value when judged by present standards, the circumstances under which the work was carried on become of interest in connection with the extensive studies which are now being prosecuted by the Maryland Geological Survey. It has long been known that incidental references to minerals were made in Smith's writings but no hint has ever been given indicating the official character of the study.

In the "instructions by way of advice, for the intended Voyage to Virginia," published in 1606, certain duties were imposed upon the captains of the companies going out to the colony. When they reached Virginia they were "to find out a safe port in the entrance of some navigable river making the choice of such a one as runneth farthest into the land, and . . . that which bendeth most toward the Northwest for that way you shall soonest find the other sea." When they had chosen a river they were to select a place "so far up as a bark of 50 tuns will float" and there to establish their settlement. When they had determined upon their location and landed supplies the six score men of the company were to be divided into three parties according to the following suggestion, "one party of them you may appoint to fortifie and build, of which you first work must be your storehouse for victuals; the other[s] you may employ in preparing your ground and sowing your corn and roots; the other ten of these forty you must leave as centinel at the haven's mouth. The other forty you may employ for two months in discovery of the river above you, and on the country about you; which charge Captain Newport and Captain Gosnold may undertake of these forty discoverers. When they do espie any high lands of hills, Captain Gosnold may take twenty of the company to cross over the lands, and carrying a half dozen pickaxes to try if they can find any minerals." They were further instructed to observe whether the river on which they planted sprung out of mountains or out of lakes. "If it be out of any lake the passage to the other sea would be more easy, and [it] is like enough, that out of the same lake you shall find some spring which run[s] the contrary way toward the East India sea." They were likewise requested to furnish a "perfect relation" of all that was done, indicating where they were located, what commodities they found and the character of the soil and woods.

From the foregoing instructions it is evident that the London Virginia Company desired their officers to make as complete a reconnaissance of the area as possible. Captains Newport and Gosnold, although especially instructed to carry out the exploratory work of the colony apparently did not visit the present territory of Maryland, and it was not until 1608, when Captain John Smith made his voyage of discovery up the Chesapeake Bay, that this particular area was explored. In a letter written by him to the "Treasurer and Councill" of Virginia in 1608, Smith gives the following summary of his surveying both topographical and mineralogical:

"Now that you know, I haue made as great a discovery as he [Newport], for lesse charge than he spendeth you every meale: I haue sent you this Mappe of the Bay and Rivers, with an annexed Relation of the Countries and Nations that inhabit them, as you may see at large. Also two barrels of stones, and such as I take to be good Iron ore at the least; so devided, as by their notes you may see in what place I found them."

No other reference is given in Smith's works to this collection of specimens, and it is probable that they were soon lost sight of when they proved of little value.

During his exploration of the Potomac he learned from the savages of the presence of a peculiar mine some distance up the Quiyongh [Aquia] Creek, and decided to visit it, although it involved a march of seven or eight miles from his boat. He gives the following description of the place: "The mine is a great Rocky mountaine like *Antimony*; wherein they digged a great hole with shells and hatchets: and hard by it, runneth a fayre brooke of *Christal*-like water, where they wash away the drosse and keepe the remainder, which they put in little baggs and sell it all ouer the country to paint theire bodyes, faces, or Idols; which makes them look like Blackmoores dusted all over with siluer. With so much as we could

carry we returned to our bo[a]te, kindly requiting this kinde king and all his kinde people.

"The cause of this discovery was to search [for] this mine, of which *Newport* did assure vs that those small baggs (we had ginen him), in *England* he had tryed to hold halfe siluer; but all we got proued of no value."

Although Smith spent scarcely a month in his exploration of the entire territory on either side of Chesapeake Bay and its upper tributaries, he clearly depicts on his well-known map of Virginia a difference in topography between the Coastal Plain and the Piedmont Plateau, representing the former without hills, except along the Calvert Cliffs, and the latter with numerous elevations. The line of demarkation as delineated corresponds quite closely with that recognized at the present time. It is described as follows:

"From the head of the Bay to the Northwest, the land is mountainous, and so in a maner from thence by a Southwest line; so that the more Southward, the farther off from the Bay are those mountaines. From which fall certaine brookes which after come to the fine principall navigable rivers. These run from the Northwest into the Southeast, and so into the West side of the Bay, where the fall of every River within 20 or 15 myles one of another."

Additional facts are given regarding the topography and soil of the State as follows: "The mountaines are of divers natures: for at the head of the Bay the rockes are of a composition like Mill stones. Some of Marble, &c. And many peeces like Christall we found, as throwne downe by water from those mountaines. For in Winter they are covered with much snow, and when it dissolveth the waters fall with such violence, that it causeth great inundations in some narrow valleys, which is scarce perceived being once in the rivers. These waters wash from the rocks such glittering tinctures, that the ground in some places seemeth as gilded, where both the rocks and the earth are so splendent to behold, that better judgements than ours might have been perswaded, they contained more than probabilities. The vesture of the earth in most places doth manifestly proue the nature of the soyle to be lusty and very rich. The colour of the earth we found in diverse places, resempleth *bole Armoniac*, *terra sigillata ad Lemnia*, Fullers earth, Marle, and divers other such appearances. But generally for the most part it is a blacke sandy mould, in some places a fat slimy clay, in other places a very barren gravell. But the best ground in knowne by the vesture it beareth, as by the greatnesse of trees, or abundance of weedes, &c."

The map also indicates an attempt to represent the differences in the character of the forest trees growing in different portions of the region examined. The foregoing facts, accordingly, clearly indicate that efforts were made to acquire information regarding the physical features, including the minerals, soils, topography, drainage, and vegetation of the territory about the Chesapeake. The actual amount of information gained, considering the time allotted, compares favorably with that of any contemporaneous explorations along the borders of the American continent, and is also not much below many of the exploring expeditions sent into the heart of Africa during the last few decades.

Two Excursions with Geological Students into the Coastal Plain of Maryland. By GEORGE BURBANK SHATTUCK.

It has been customary for the students of geology in this University to make frequent excursions, during the autumn, to localities of special interest in the vicinity of Baltimore, for the purpose of studying in the field the phenomena which are systematically discussed in the lecture room. Thus far this season two excursions have been conducted into the Coastal Plain region, and others are already planned for the Piedmont Plateau. The first excursion took place on October 15, with Round Bay and Winchester as objective points. On the second, which took place one week later, Bodkin Point, at the mouth of the Patapsco, and Gibson Island, at the mouth of the Magothy river, were visited.

Round Bay is the name given to that portion of the Severn river lying between Cedar and Arnold Points, where the stream suddenly changes its character from a narrow estuary confined between high banks, to that of a broad, lake-like expanse. On the northeastern shore of this body of water a series of deposits, extending from lower Cretaceous to Eocene, is exposed in the high, vertical walls of the valley.

The most comprehensive section is laid bare on the sides of Mt. Misery, and may be briefly summarized as follows: The Raritan formation (lower Cretaceous), which lies at the base, is represented by a thin band of dark, bluish clay overlaid by a bed of coarse, white, cross-bedded sand, eight feet thick, which in turn is capped with a four-inch ferruginous band. Above this the Matawan (basal member of the upper Cretaceous) lies unconformably, and is composed of dark, glauconitic, fossiliferous clay, grading upward into a light-colored, sandy clay, in all attaining a thickness of some twenty-two feet. Conformably on this rests the Monmouth formation with four feet of green sand at base, overlaid by eight feet of white and red sand carrying marly layers. From here upward for some distance the section is obscured by landslips and vegetation, but just below the one hundred foot contour the marls of the Rancocas formation appear, and forty feet below the top of Mt. Misery are unconformably overlain with a coarse fossil-bearing sand-tone of Eocene age. About a mile northwest of Mt. Misery, in the vicinity of Cedar Point, the Raritan section is considerably thicker, and contains rolled, clay lumps evidently derived from underlying members of the Potomac group, which had been raised above sea level and were undergoing erosion at the time that the sands in this locality were being deposited. This whole series of formations enters Maryland from the neighboring state of Delaware, crosses the state from northeast to southwest, and slopes toward the southeast with an average dip of twenty-five feet to the mile, although locally it may depart somewhat from this angle. Owing to this dip the various beds, as they proceed toward the Chesapeake, successively approach the water line, skirt along the shore for a short distance, and finally disappear, one by one, beneath the waves.

At Winchester, a station on the Baltimore and Annapolis Short Line, about four miles down the dip from Round Bay, the Eocene deposits are beautifully exposed in an extensive railroad cutting. Here the formation is made up largely of fine sand carrying a little glauconite, and is stratigraphically higher and younger than the Eocene deposits which cap Mt. Misery. Although the deposits as a whole are not consolidated, nevertheless a partial induration has succeeded in binding the otherwise loose sand into a more coherent mass. Iron has largely served as the cement, and beautiful examples of concentric, cylindrical crusts are here visible. Fossils in the form of poorly preserved casts occur near the base of this cutting.

Through the courtesy of Hon. William T. Malster, who generously placed the steamboat "Baltimore" at the disposal of the Geological Department, the excursion to Bodkin Point and Magothy river was rendered more than usually enjoyable. Along the shore, about a mile below Bodkin Point, the variegated clays of the Raritan formation are finely exposed in a cliff some thirty feet in height. These clays occupy the greater portion of the section and carry an abundance of lignite more or less incrustated with crystals of pyrite. Sands and gravels of Pleistocene age unconformably overlie the clays and constitute the upper portion of the cliff. Half a mile further south the cliff still maintains its former height, but the section has changed. Some ancient stream must have established its valley on the Raritan sand, for here the surface of that formation, like a great concave depression, passes gradually beneath the beach to appear again in the cliff a hundred and fifty yards below. In this hollow, lying unconformably on the Raritan formation, is a bed of dark-colored clay about fifteen feet thick. Bluish and greenish tinted bands of clay relieve somewhat the somber aspect of this formation, and at about its middle portion it carries a bed of peat. But its most striking feature is the huge fossil cypress knees and stumps which are imbedded in its lower portion. These stumps vary in diameter from two to over ten feet, and after the removal of the surrounding clay, stand out prominently in the position in which they must have grown. Mr. A. Bibbins, to whom I am indebted for the above measurements, has counted thirty-two of these stumps which were visible at one time, and also reports finding worm-eaten beechnuts intimately associated with cypress cones near the base of the formation.¹ Sands and gravels of Pleistocene age overlie the whole unconformably. Immediately south of this outcrop the dark-colored clays are temporarily replaced by the Raritan formation, but they appear again a little further down the shore, and afford a good and almost unbroken exposure for about a mile. The thickness of the clay in this locality is at first about ten or twelve feet, but it gradually becomes thinner southward and finally disappears altogether. Casts of *Unio* shells, and

¹This is the same deposit which has been described by Mr. A. Bibbins (*Plant World* Vol. I, 1898, pp. 164-166, with plate) as Raritan, but the writer believes it is very much younger.

not vegetable remains, are its predominant fossils, while, like the beds containing the cypress swamp, it overlies the Raritan formation unconformably, and is itself unconformably buried beneath Pleistocene sands and gravel.

The peculiar topographic relations and physical composition of the clays in these two exposures call to mind other deposits of similar character which the writer has examined at several localities in other parts of Maryland. Perhaps the most striking of these deposits is exposed on the Bay shore, about a mile northeast of Drum Point. Here, at the base of a cliff about thirty feet high, is a two foot bed of dark, chocolate colored clay carrying gnarled and twisted sticks protruding in every direction from the material in which they are imbedded. Above this occurs a thin seam of lignite one and a half feet thick, which in turn is overlain with about five feet of slate-colored clay. At this point the continuity of the deposit is interrupted by an unconformable series of sands, clays and gravels, of Pleistocene age, which extend upward to the top of the cliff. Although the base of this lignitic clay series is buried beneath beach sands, yet field relations lead to the conclusion that the deposit is very much younger than the Miocene clays on which it is believed to rest unconformably. A similar section is to be seen on the Patuxent river, about a mile below Soller's Landing. Large stumps here protrude from a dark, basal clay bed, some five feet in thickness, which is covered by three feet of sand, and this again buried unconformably beneath ten feet of Pleistocene sand and gravel. The relations of the basal clay to the underlying Miocene is again obscure, but indications point to an unconformity. A third section is exposed along the shore one and one-half miles northwest of Cedar Point, where a thin bed of drab clay carrying vegetable remains is overlain unconformably with sands and gravels. Its contact with the Miocene is again unfortunately obscure. At the three localities just described no animal remains have been discovered, but on the north bank of the Potomac, about half way between St. Mary's River and Breton Bay, there is a deposit of lead-colored clay, exposed for a quarter of a mile along the shore. Buried at each end as well as above by sands and gravels, it carries both lignite and *Gnathodon cuneata* Conr., and shows by its unconformability with the gravels that it was raised and considerably eroded before they were deposited. Although the description given by Conrad is somewhat vague, it is highly probable that he visited this locality and collected specimens of the fossils. Two more localities still remain to be mentioned, Cornfield Harbor, and its companion deposit exposed five and a half miles south of Cedar Point on the Bay shore. Conrad was well acquainted with these deposits and to the former he devoted special attention. Each is about ten feet thick, occurs at the base of a low cliff, is composed mostly of a dark, lead-colored clay, and is overlain unconformably with Pleistocene sand and gravel, while unconformity on the Miocene is beautifully shown at the base of the Bay shore section. A number of fossils have been described from the Cornfield Harbor locality, among which are *Ostrea Virginica* Gmelin, *Arca ponderosa* Say, *Arca transversa* Say, *Venus mercenaria* Linn., *Mya arenaria* Linn., *Pholas costata* Linn., *Crepidula plana* Say, *Natica duplicata* Say, *Busycon carica* Gmelin. Of these many and possibly all occur in the Bay shore deposit.

It will now be seen that these deposits, scattered along the margin of Chesapeake Bay from the buried cypress swamp below Bodkin Point to the classic locality near Cornfield Harbor, all strikingly resemble each other: for they are composed of dark, compact clay, occur at tide, at the base of low cliffs whose tops are far beneath the general level of the surrounding country, along ancient river channels, have suffered considerable erosion, are unconformably buried beneath Pleistocene strata, and are unconformable on the older deposits wherever the contact is visible. The point in which they differ most widely is in the character of their organic remains, but this contrast is just what one would expect to find if the deposition of the lignitic clay took place in fresh water swamps, while the other beds were laid down in regions more easily influenced by the ocean. Similar deposits are being formed side by side along our coast to-day.

One cannot see these deposits without being strongly impressed with their similarity to the Fish House clays of New Jersey. Whether all or any of them are contemporaneous is not known, and a comprehensive definition or reliable correlation would, at the present state of our knowledge, be premature, but one cannot help feeling that these various deposits, from Fish House to Cornfield Harbor may prove, in the light of further investigation, to be isolated remnants of the same geologic formation.

The expedition concluded with an examination of the cliff on the south side of Gibson Island, facing the Magothy. Upper Cretaceous beds compose most of this section, and the Matawan, Monmouth, and Rancocas formations may be seen finely exposed in the bank.

Johns Hopkins University, November 2, 1898.

An Episode during the Terrace Cutting of the Potomac. By CLEVELAND ABBE, JR.

While studying the graveled terraces which are marked features of the Potomac valley in the vicinity of Cumberland, Maryland, the writer came upon a very interesting piece of evidence of stream action during one of the earlier terracing epochs.

Five or six miles west of Cumberland the Baltimore and Ohio Railroad passes a cliff of vertically bedded Lewistown limestone and Rockwood shales on the northwest bank of the Potomac river. The shales are very fissile and generally thin bedded between thin bands of an impure limestone; while the Lewistown limestone is relatively more massive. These physical characters and their vertical attitude combine to make the cliffs easily and rapidly scored by the agents of denudation and erosion and the result is that deep aisles or shafts have been carved in the cliffs by wind and rain. In one of the less resistant bands of the Lewistown limestone, very near the top of the shales and about 50 yards from "Potomac Station" a cave has been hollowed out. This cave or recess at present has a width of eight or nine feet, a height of fifteen feet above the railroad bed and a depth of ten feet in from the face of the cliff. These measurements however, do not indicate the original size of the cave. The cutting necessary for the construction of the railroad bed has removed twelve or fourteen feet of the bank so that an equal number of feet should probably be added to the present depth in order to obtain a measure of the original depth of the cave; and the maximum height and width are masked by the road bed and removal of material.

As first seen from the railroad track the cave appears rather commonplace since there are numerous smaller recesses worn out from the soft shales of the vicinity as has been observed above. A second look, however, revealed some interesting points. In the back part of the cave was noticed a massing of fragments of shale and limestone with their flat sides laid horizontally, while above and around them the rocks stand with their clearly defined bedding planes in a vertical position. On entering the recess and examining the interior more closely it was at once evident that the cave had been filled with a mass of stratified gravels, sandy clay and angular or subangular shale fragments. The floor of the cave is sandy clay strewn with gravels and cobbles some of which lie in a heap at the entrance, while at the back of the recess and along the right side a considerable volume of the filling material still stands *in situ*. To a height of four or five feet from the present cave floor the filling material is a sandy clay packed with well rounded quartz gravels averaging $\frac{3}{4}$ to 1 inch in diameter. The pebbles are most thickly set near the base, becoming somewhat more loosely clustered four or five feet up. Occasionally this gravelly layer contains large rounded quartz cobbles 12 to 15 inches in diameter. No large cobbles were seen in place, but three or four of them lying on the present cave floor would seem to have come from this layer since it is the most suitable and nearest source. There is no convenient external source for them and although the cave shows signs of recent human occupation there seems to be no reasonable motive for the introduction of the cobbles through human agencies. The gravel and cobble layer is overlain by one and a half or two feet of the clay with rarely a pebble or fragment of shale. At the top a bed of angular fragments of shale and one or two quartz pebbles, extends nearly or quite to the roof of the cave. The walls of the cave show such evidences of solvent action as commonly characterize the soluble limestone outcrops in the fields, although here within the cave the effects of the solution are less pronounced. Because of this solvent action it was difficult to determine with certainty whether or no the cave walls had suffered any corrosion by the action of running water, and no clear evidence of such action was found.

Significance of the Cave-deposits.—It is a significant feature of the deposit in the cave that its character changes from gravels and cobbles in its lower

portion to clays and angular fragments of shale at the top. The large gravels and cobbles composing the lower four or five feet of the deposit clearly indicate that during the earlier part of the cave's history strong stream currents were flowing through and past the cave. In no other way can we account for the presence in the cave, of well rounded gravels of a material so foreign to the locality as vein quartz is. During this period any fragments of limestone that may have fallen from the roof or been torn from the sides seem to have been ground to pieces by the rushing waters and carried away for no fragments were found mixed with the gravels of the deposits. The upper portion of the deposit is sharply distinguished from the lower by its clay bed and the absence of quartz gravel, the latter's place being taken by the fragments of shale. All these features indicate that the waters in the cave were much quieter during the later stages of its history. While the one or two feet of clay were being formed the waters must have been much quieter and loaded only with silt and sand, a condition most plausibly explained in this case by supposing the stream to have shifted its channel so that only the slower currents reached the cave. The upper layer of unworn angular shale fragments probably indicates a slight increase in the force of the current flowing by the cave, but not a return of the earlier conditions. The question of the source of these shale fragments is of interest. They may have been brought in from the ledges of shale that are now just outside the cave; or it may be that the cave formerly extended beyond its present limits in the limestone and included a portion of the neighboring shales and that these fragments were thus derived from the former walls of the cave itself. In either case the angular shapes of the fragments indicate that they were not transported over any considerable distance and that the currents were not very swift.

Relation of Cave and Gravels to Terraces.—The chief interest that this river cave possesses arises from its relations to the stream terraces and gravels in its vicinity. There are along this portion of the Potomac two different terrace-levels above the present bottom-lands or flood plain of the Potomac. The flood plain is itself somewhat easily to be mistaken for a terrace since it stands six or eight feet above the channel of the river and is cultivated. The front of the first terrace rises rapidly from its sinuous intersection with the floodplain, to an elevation of about twenty feet above it and then changes to the very gently sloping bench that extends back three hundred feet to the front of the second terrace. Along the front of the second terrace and on the surface of the first terrace run the tracks of the Baltimore and Ohio Railroad. The second terrace rises twenty to twenty-five feet above the level of the railroad tracks and always has a much more sharply marked and steeper slope than the first terrace but it is also much more extensively dissected by recent drainage lines. This second terrace, as is described in another paper, is strewn with gravels and cobbles to a depth of two or three feet yet a section cut in it by a small stream near Cedar Cliff station proves conclusively that the terrace owes its origin more to the planing down of the yielding shales of the Lewistown than to the constructive action of the river.

These two terraces with less distinct traces of a third higher one can be traced more or less continuously along the Potomac for a number of miles. The main interest attaching to them for our present discussion arises from the coincidence in elevation above present stream channels, of the second terrace front and the gravel-filled cavern already described.

History of the Cave.—The two features of the cave that seem to be most important are, first, that it stands not in the face of the front slope of the second terrace, but is hollowed out at a corresponding elevation in a higher cliff (at whose base the Potomac now runs); and second, that it is filled with stream-worn gravels and boulders.

First, let us consider the question of origin of the cave. There are two hypotheses according to either one of which the existence of the cave might be explained. (a) The cave may be the product of subterranean stream action, having been dissolved out of the limestone by some small stream that trickled down through the vertical joint-planes and laminae of the rock. This explanation is supported by the fact that the walls of the cave do show signs of solvent action and that it has the narrow rather angular features of a subterranean water course. The absence of any indications of a stream channel or inlet is against the theory. The filling of gravel may, however, mask such an entrance. (b) Again we may regard the cave as having been hollowed out by the lateral cutting of the river when it stood at this level and swept against this bank as it does to-day. The presence in the cave-deposit of the large rounded quartz boulders proves that there

were strong currents flowing past the cave during the deposition of the earlier portion of its filling. This suggests that the rapid flowing stream armed with flint as it was, wore away the yielding rocks at this point where the river turned against them most sharply, hollowing out a shallower, broader cavern whose inner portion only is now revealed to us. Such an origin for the cave would leave its marks on the walls of the latter in the form of abrasion marks, and would also leave slight traces of solvent action by the waters carrying the abrasive materials. The walls of the cave do not show any markings that may be definitely assigned to stream wear such as has been suggested. Solution has clearly borne some part in the cavern's growth for as has already been noticed the walls show the rounded and smoothed corners and edges that characterize such work. Such results may have come through subterranean stream action, however, as easily as from river work and do not in themselves yield any criterion for the determination of the agent.

There are, therefore, no definite lines of evidence on which to base a final explanation of this cave. The clearest and most striking facts, particularly the presence of large, rounded quartz boulders and the probable long continued concentration of stream force at or near this point, give strong presumption in favor of origin by lateral or horizontal corrosion. It is possible, perhaps even probable that this horizontal corrosion by the gravel-loaded stream was definitely concentrated at this point by the cavern of a small subterranean stream.

The period of this cavern-cutting is indicated by the relation between the cave-gravels and the terraces with their gravel-veneer. The cave, by its location must have been formed during the period when the river was cutting down from the Second Terrace to the First Terrace. Standing as it does between the elevations of the front top of the Second Terrace and the back of the First Terrace the position of the cave is just where a stream cutting down from terrace to terrace would be likely to hollow out a recess during its progress downwards. The gravels now lying in the cave are most closely connected, through elevation, with the gravels lying on the First Terrace and the front slope of the Second. They rise higher than these latter gravels but not quite to the level of the Second Terrace, whence one infers that these cave-gravels are, like the cave, intermediate in age between the older Second Terrace and the younger First Terrace. The writer has not as yet definitely correlated these terraces about Cumberland with the Pleistocene deposits lower down the Potomac.

REPORT OF THE WORK OF THE GEOLOGICAL DEPARTMENT DURING THE SESSION

OF 1897-98.

By W. B. CLARK.

The Geological Laboratory was open daily throughout the year to graduate and undergraduate students. The quarters have been considerably enlarged by the addition of a series of rooms upon the lower floor of the rear building attached to Hopkins Hall, as well as by the construction of a machine shop for the conduct of the experimental work connected with the Maryland Geological Survey.

The instruction in Geology has been somewhat modified by the withdrawal of Mr. G. K. Gilbert of the U. S. Geological Survey who for several sessions delivered important courses of lectures upon physiographic geology. Professor Cleveland Abbe of the U. S. Weather Bureau has been attached to the corps of instructors and will give a few lectures upon meteorological topics in the future.

During the past year the following courses of instruction were given:

(a) General Geology, by Professor Clark and Dr. Shattuck. *Four lectures and one afternoon in practical work each week throughout the year.*

(b) Historical Geology, by Professor Clark. *Two lectures each week throughout the year.*

(c) Geological Physics, by Associate Professor Reid. *Two lectures each week from February to May.*

(d) Mineralogy, by Dr. Mathews. *Three lectures each week throughout the year.*

(e) Petrography, by Dr. Mathews. *Two lectures each week from October to February.*

(f) Climatology, by Mr. Fassig. *Fifteen lectures in October and November.*
 (g) Stratigraphic and Structural Geology, by Mr. Willis. *Two lectures each week from March to June.*

(h) Scandinavian Geology, by Professor Hans Reusch. *One lecture in March.*

(i) Topographic Methods, by Mr. H. M. Wilson. *Three lectures in May.*

(j) Rocks and Rock Weathering, by Professor G. P. Merrill. *One lecture in November.*

(k) Geological Conferences. *Fortnightly throughout the year.*

(l) Student lectures. *Fortnightly from December to May.*

Original Work and Publications. Geological work was continued by Professor Clark upon the older Coastal Plain deposits of the Middle Atlantic Slope with the cooperation of Dr. R. M. Bagg, Jr., and Mr. A. Bibbins. A report was prepared for the Geological Survey of New Jersey upon the Cretaceous formations of that State. Several other papers were published on various phases of Coastal Plain work. Professor Clark also contributed an article to the *Journal of Geology* in "A Symposium on the Classification and Nomenclature of Geologic Time Divisions." Professor Clark was actively employed throughout the year in the management of the State Geological Survey and in the preparation for publication of the second volume of its reports.

Associate Professor Reid, as a member for the United States of the International Committee on Glaciers, was engaged in collecting information regarding the various American glaciers. He continued his work upon the movement and stratigraphy of glacier ice, spending a portion of the summer and autumn of 1897 in eastern Switzerland in the accumulation of additional data. Dr. Reid is Chief of the Division of Highways of the Maryland Geological Survey.

Dr. Mathews continued his investigations upon the crystalline rocks of the northern counties of the State. He made an extended study of the building-stones of Maryland and the industries founded thereon, and has prepared an elaborate monograph in connection with Professor Merrill of the U. S. National Museum upon this subject. Dr. Mathews has also been engaged during a portion of the year in an investigation of the maps and map-makers of Maryland, which he will present in the form of a report in the next volume of the Maryland Geological Survey. As Assistant State Geologist, Dr. Mathews was also engaged in the management of the State Geological Survey.

Mr. Fassig, in addition to his work in connection with the Baltimore office of the U. S. Weather Bureau, has been making a study of the history of climatological investigations in Maryland, preparatory to the publication of a report upon that subject in the new series of the Maryland Weather Service.

Dr. Shattuck began, during the summer and autumn of 1897, a study of the gravels about the head of Chesapeake Bay, preparatory to the mapping of the several gravel formations of the eastern section of the State. This work was continued on a wider scale the present summer. Dr. Shattuck also investigated the Tertiary fossils secured by Professor Robert T. Hill, of the U. S. Geological Survey in Jamaica, and will prepare a palaeontological paper to accompany Professor Hill's report upon the geology of that island.

Three candidates presented themselves in June for the degree of Doctor of Philosophy. The first, Mr. Cleveland Abbe, Jr., carried on an investigation upon the physiography of the State with especial reference to the development of the streams of the Piedmont Plateau, and his report will be published by the State Geological Survey; the second, Mr. C. C. O'Harra, carried on a very thorough investigation of the stratigraphy, structure, and mineral resources of Allegany county which will be published both as a special report and as part of a later volume upon the descriptive geology of Maryland; the third, Mr. A. G. Leonard, was engaged in a study of the relations of the basic to the acid eruptive rocks of Cecil county, an investigation started during a period of earlier academic residence under the direction of Professor Williams. The results of this investigation will be published as a Bulletin of the U. S. Geological Survey.

Several other investigations were undertaken by different members of the Department and will result in later communications.

Excursions and Geological Camp. Numerous short excursions were made during the autumn months into the region immediately adjacent to Baltimore, both in the Coastal Plain and the Piedmont Plateau. The long excursion commonly made in the spring was replaced by the establishment

of a permanent camp in the vicinity of Cumberland in the heart of the Appalachian Mountains, where, under the several instructors, the regular work of the Department was continued during several weeks in May. Special lecturers connected with the scientific bureaus in Washington were secured, who gave practical instruction to the students in field methods, in climatology, topography, hydrography, and agricultural soils. These subjects were daily studied as well as the more important problems presented by the geology of the district.

Scientific Societies. The fortnightly meetings of the Geological Society of Washington were attended from time to time during the winter by the instructors and students of the Department, all of whom were elected non-resident members of that organization. Several members of the Department also became members of the National Geographic Society and availed themselves of its privileges. The results of many of the most noteworthy investigations of the year are presented to these societies, and attendance at the meetings is considered an important part of the students' work.

International Geological Congress. Professor Clark and Dr. Reid were in attendance as delegates from the University (Professor Clark was one of the National delegates, and also carried the credentials of the Governor of Maryland as State Geologist) at the Seventh International Congress of Geologists at St. Petersburg during the summer and autumn of 1897. They were allowed a period of absence for the early part of the academic year, and during this time extended their travels throughout European Russia as well as into the adjacent Asiatic provinces. They brought back valuable materials for the University collections.

Professor Clark was appointed a member of the International Committee on the Unification of Geological Nomenclature, and Dr. Reid a member of the Committee on Glaciers.

The Abbe Meteorological Library. Professor Cleveland Abbe, of the U. S. Weather Bureau, presented to the University, during the year, his important collection of books upon meteorological subjects. This library is regarded as one of the most complete in this country, and will prove of great value to students who are intending to carry on investigations in the field of meteorology. The library has been already placed in a room in the Geological Laboratory especially prepared for it, and Mr. Fassig acts as special librarian of the collection. This generous gift of Professor Abbe is very highly appreciated, and it is believed that it will do much to arouse an interest in meteorology in Maryland.

Apparatus and Collections. Several important additions were made to the apparatus and collections during the year. The library was considerably enlarged by the addition of several important serials and much needed geological maps. Several valuable collections of rocks and fossils were also acquired.

COLLECTION OF EOCENE FOSSILS.

A large number of Maryland and Virginia Eocene fossils have been secured during the past season by Dr. R. M. Bagg. This new material will very largely enhance the value of the collections of the University from this horizon, especially since many new species have been found, and the already recognized forms so largely increased in number of individuals as to give better comparative material.

Highly important results have been secured from a stratigraphic standpoint since the boundary between the two Maryland Eocene faunas has been definitely determined at many points. These results will make it possible to represent upon the State maps the two different divisions of the Maryland Eocene.

The writer desires to correct the use of the name *Pecten rogersi*, applied to a new species of this genus from the Middle Atlantic slope Eocene in an earlier report,¹ on the ground of the pre-occupation of the term. The name *Pecten dalli* is proposed in its place, and will be incorporated in the report upon the Maryland Eocene which will be later published. The species referred to was secured from Potomac Creek, Virginia, and belongs to the lower or Acquia Creek fauna.

W. B. C.

¹J. H. U. Circulars, Vol. XV, p. 5, 1895; Bull. U. S. Geol. Surv., No. 141, p. 85, pl. XXXIV, figs. 2a-c, 1896.

PUBLICATIONS OF THE MARYLAND GEOLOGICAL SURVEY.

The Maryland Geological Survey has already published several articles relating to the physical features of Maryland. Most of these have been brought together in Volume I of the series of Survey reports, which appeared in July, 1897. This first volume contains historical and geological chapters regarding the present knowledge of Maryland geology together with a complete geological bibliography and cartography of the State. An exhaustive report upon the magnetic conditions of Maryland is also included in this volume. These several articles have been published both as independent reports and combined in volume form.

Since the publication of the first volume a report has been issued upon the Survey of the Boundary-line between Allegany and Garrett counties, which appeared in September of the present year. Other reports dealing with the Building Stones of the State and with the Maps and Map-makers of Maryland, the latter introduced by a chapter upon the Aims and Methods of Topography, have been prepared. These will constitute Volume II of the series of official reports, and will be issued from the press during the current month.

Other reports dealing with the Physiography of the State and the detailed geological features of portions of Western Maryland are already in manuscript and will be issued as Volume III as soon as the proper base-maps can be prepared.

Much progress has already been made in the preparation of the manuscript of the Report upon Highway Construction which will constitute Volume IV, and which is required by legislative act to be presented at or prior to the next session of the General Assembly in January, 1900.

These four volumes, already printed or in manuscript, will present to the people of the State a discussion of many subjects of economic and educational importance. Much additional material has been already collected which can be in the near future brought together in the form of reports. Some of this work will be delayed in publication until the preparation of the necessary topographic maps which are now under construction by a plan of coöperation with the U. S. Geological Survey which was authorized by the last session of the General Assembly.

W. B. C.

LECTURES IN GEOLOGY AND PHYSICAL GEOGRAPHY FOR BALTIMORE TEACHERS.

In response to a request for lectures especially adapted to the needs of Baltimore teachers, the Johns Hopkins University offers, during the current academic season, two classes of instruction: one on historical, the other on scientific subjects.

The Scientific Course which embraces lectures in Geology and Physical Geography, began on Saturday, November 5, 1898, at 9.30 a. m., in McCoy Hall, and will continue at the same hour on successive Saturdays until the course is completed. The lectures will be chiefly given by Dr. George B. Shattuck.

Bibliographies and printed outlines of each lecture are furnished without expense to the hearers. Each lecture is preceded by a review of the previous lecture. Questions for written answers, which may be sent to the lecturer by those who are so inclined, are given out from time to time, or printed in the syllabus, for the purpose of stimulating study at home. A written examination will be set at the end of each course, and the papers submitted will be returned to the writers with corrections or helpful suggestions. A simple certificate covering attendance and class work will be given at the end of the Course.

The following is a syllabus of the lectures given:

November 5, Atmosphere; 12, Rain; 19, Rivers in General.
 December 3, Classification of Rivers; 10, Life history of Niagara; 17, Lakes.
 January 7, Oceans; 14, Ice in General; 21, Glaciers; 28, Organisms.
 February 4, Volcanoes; 11, Mountain Building and Uplift in General; 18, Distribution; 25, Paleontology.
 March 4, Precambrian; 11, Paleozoic; 18, Mesozoic; 25, Tertiary.
 April 8, Quarternary; 15, History.

Professor Clark opened the Course in a short address explaining the methods to be pursued, and introduced the lecturer. The hearty response on the part of the teachers is very gratifying to the committee in charge of the Teachers' Course. At the present time the class numbers one hundred and seven while ninety more teachers attend the lectures.

G. B. S.

At a meeting of the Zoölogical Journal Club of the Johns Hopkins University, November 7th, 1898, Dr. H. McE. Knowler told of the sudden death, on November 4th, of Dr. JAMES INGRAHAM PECK, Assistant Professor of Biology in Williams College, and Sub-Director of the Marine Biological Laboratory of Wood's Holl, Mass.

As Dr. Peck had been associated, while a student in the Johns Hopkins Biological Laboratory, with some of those present, a special meeting was called to afford an opportunity for an expression of the sorrow felt in the loss of one whose short life had been so full of usefulness.

On the following day, those who had been instructors and fellow students of Dr. Peck in this University met together, with many who had known him and studied under him at Williams College and at Wood's Holl, and adopted the following minute:—

Whereas, we cannot forget that James Ingraham Peck exemplified, in his own short life, all those high qualities of enthusiasm for truth, of devotion to scientific research, and of earnestness in the instruction of others, which it is the chief aim and best reward of a university to diffuse among men;

We therefore resolve, that while we mourn the untimely loss of one who had been the earnest and faithful pupil of some among us, the enthusiastic and inspiring fellow student, or the patient, kindly, and helpful teacher of others, we are glad to remember his devotion to the highest and best work of a learned man, and his success in handing on to his associates his unselfish enthusiasm in the pursuit of truth.

And be it further resolved, that copies of these resolutions be sent to the family of Dr. Peck, and to the Johns Hopkins University Circular.

DANIEL C. GILMAN, *President, Johns Hopkins University.*

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